

# CENTRAL VALLEY FLOOD MANAGEMENT PLANNING PROGRAM

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## Flood Control System Status Report Appendix A – Levee Status

December 2011

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## Appendix A – Levee Status

Appendix A provides additional supporting information on levee physical conditions. The levee status overview includes data that reflect the impacts of multiple levee status factors on levee conditions. These data include information from U.S. Army Corps of Engineers (USACE) Periodic Inspection results, historical levee breaches and overtopping locations, and a summary of Early Implementation Program projects, Central Valley Flood Protection Board (Board) projects, and other modifications to SPFC facilities. Sections A-2 through A-10 of Appendix A are organized by levee status factors, and correspond to the subsections in Section 4 of the Flood Control System Status Report (FCSSR) main document. Additional inspection and/or evaluation data, recent, ongoing, and planned remedial actions/improvements, and ongoing actions to improve future evaluations are described for each levee status factor.

### A-1 Levee Status Overview

This section presents USACE Periodic Inspection results, contains data on historical levee breaches and levee overtopping locations, Early Implementation Program and USACE/Board projects, and other modifications to State Plan of Flood Control (SPFC) facilities.

#### **USACE Periodic Inspection Report Cards**

USACE Periodic Inspections are conducted to verify proper operations and maintenance (O&M); evaluate operational adequacy and structural stability; identify features to monitor over time; and improve communication regarding overall facility condition and safety. USACE conducts its Periodic Inspections to rate flood damage reduction systems. A flood damage reduction system is a complete and independent unit made up of one or more flood damage reduction segments that collectively provide flood damage reduction to a defined area. Failure of one segment within a system constitutes failure of the entire system. The following 10 USACE systems were inspected between December 2009 and February 2010.

- City of Marysville, Units 1, 2, and 3 System
- City of Marysville, Unit 3 Northeast Extension System

## Flood Control System Status Report

- American River Flood Control District – Dry Creek Right Bank, Unit 8 System
- American River Flood Control District – Dry Creek, Natomas East Main Drainage Canal, and Arcade Creek System
- American River Flood Control District – American River Right Bank, Natomas East Main Drainage Canal System
- Reclamation District 1000 – Natomas System
- Feather River Right Bank – Sutter Bypass East Bank Levee System
- Maintenance Area 9 – City of Sacramento, American River Left Bank System
- Reclamation District 404 and Duck Creek Right Bank – Boggs Tract System
- Reclamation Districts 17, 2094, 2096, 2075, and 2064 – San Joaquin River East Levee System

Report cards serve as a findings summary of USACE Periodic Inspections. Tables A-1 through A-10 display Periodic Inspection Report Cards for each system.

**Table A-1. City of Marysville – Units 1, 2, 3 System Report Card**

City of Marysville - Units 1, 2, 3 Unacceptable-Inactive	Unit 1 Jack Slough	Unit 2 Feather River	Unit 3 Yuba River						
Operations and Maintenance Manuals	M	M	M						
Emergency Supplies and Equipment	A	A	A						
Flood Preparedness and Training	M	M	M						
Unwanted Vegetation Growth	U	U	U						
Sod Cover	A	A	A						
Encroachments	U	U	U						
Closure Structures	A	A	A						
Slope Stability	U	A	M						
Erosion/Bank Caving	M	M	M						
Settlement	A	A	A						
Depressions/Rutting	U	A	A						
Cracking	U	A	A						
Animal Control	M	M	M						
Culverts/Discharge Pipes	NA	NA	NA						
Riprap Revetments & Bank Protection	NA	NA	M						
Revetments other than Riprap	NA	NA	NA						
Underseepage Relief Wells/Toe Drainage Systems	NA	NA	NA						
Seepage	A	A	A						
<div> <div>Segment &amp; System Ratings/PL 84-99 Eligibility</div> <div> <div>Likely Prevents Performance in Next Flood Event</div> <div>Serious deficiency noted in past inspections has not been corrected within the established timeframe</div> <div>Likely Prevents Performance in Next Flood Event (Framework)</div> <div>Not Likely to Prevent Performance in Next Flood Event</div> <div>Not Likely to Prevent Performance in Next Flood Event (Framework)</div> <div>The lowest rating is used to determine the overall segment &amp; system ratings and PL 84-99 Rehabilitation Eligibility</div> </div> <div> <div>Legend</div> <div> <div>A Acceptable</div> <div>M Minimally Acceptable</div> <div>U Unacceptable</div> <div>N/A Not Applicable</div> </div> </div> </div>									
									July 6, 2010

**Table A-2. City of Marysville – Unit 3 Northeast Extension Report Card**

City of Marysville Unit 3, NE Extension Unacceptable-Inactive	Unit 3, NE Extension								
Operations and Maintenance Manuals	M								
Emergency Supplies and Equipment	A								
Flood Preparedness and Training	M								
Unwanted Vegetation Growth	U								
Sod Cover	A								
Encroachments	U								
Closure Structures	NA								
Slope Stability	A								
Erosion/Bank Caving	M								
Settlement	A								
Depressions/Rutting	A								
Cracking	A								
Animal Control	M								
Culverts/Discharge Pipes	NA								
Riprap Revetments & Bank Protection	NA								
Revetments other than Riprap	NA								
Underseepage Relief Wells/Toe Drainage Systems	NA								
Seepage	A								
Segment & System Ratings/PL 84-99 Eligibility Likely Prevents Performance In Next Flood Event Serious deficiency noted in past inspections has not been corrected within the established timeframe Likely Prevents Performance In Next Flood Event (Framework) Not Likely to Prevent Performance In Next Flood Event Not Likely to Prevent Performance In Next Flood Event (Framework) The lowest rating is used to determine the overall segment & system ratings and PL 84-99 Rehabilitation Eligibility									
						<b>Legend</b> A Acceptable M Minimally Acceptable U Unacceptable N/A Not Applicable			
						July 6, 2010			

**Table A-3. American River Flood Control District – Dry Creek Right Bank, Unit 8 System Report Card**

American River FCD - Dry Creek Right Bank, Unit 8 Minimally Acceptable-Active	Dry Creek Right Bank, Unit 8								
Operations and Maintenance Manuals	M								
Emergency Supplies and Equipment	A								
Flood Preparedness and Training	A								
Unwanted Vegetation Growth	A								
Sod Cover	A								
Encroachments	U								
Closure Structures	A								
Slope Stability	A								
Erosion/Bank Caving	A								
Settlement	A								
Depressions/Rutting	M								
Cracking	A								
Animal Control	M								
Culverts/Discharge Pipes	N/A								
Riprap Revetments & Bank Protection	A								
Revetments other than Riprap	A								
Underseepage Relief Wells/Toe Drainage Systems	A								
Seepage	A								
Segment & System Ratings/PL 84-99 Eligibility Likely Prevents Performance In Next Flood Event Serious deficiency noted in past inspections has not been corrected within the established timeframe Likely Prevents Performance In Next Flood Event (Framework) Not Likely to Prevent Performance In Next Flood Event Not Likely to Prevent Performance In Next Flood Event (Framework) The lowest rating is used to determine the overall segment & system ratings and PL 84-99 Rehabilitation Eligibility									
						<b>Legend</b> A Acceptable M Minimally Acceptable U Unacceptable N/A Not Applicable			
						July 6, 2010			

**Table A-4. American River Flood Control District – Dry Creek, Natomas East Main Drainage Canal, Arcade Creek System Report Card**

American River FCD - Dry Creek, NEMDC, Arcade Creek Minimally Acceptable-Active	Dry Creek Left Bank Unit 6	NEMDC Unit 2 North	Arcade Creek right bank Unit 7					
Operations and Maintenance Manuals	M	M	M					
Emergency Supplies and Equipment	A	A	A					
Flood Preparedness and Training	A	A	A					
Unwanted Vegetation Growth	U	U	U					
Sod Cover	A	M	A					
Encroachments	U	U	U					
Closure Structures	A	N/A	A					
Slope Stability	A	A	A					
Erosion/Bank Caving	A	M	A					
Settlement	A	A	A					
Depressions/Rutting	A	A	A					
Cracking	A	A	A					
Animal Control	M	M	M					
Culverts/Discharge Pipes	N/A	N/A	N/A					
Riprap Revetments & Bank Protection	A	N/A	N/A					
Revetments other than Riprap	A	N/A	N/A					
Underseepage Relief Wells/Toe Drainage Systems	N/A	N/A	N/A					
Seepage	A	A	A					
<b>Segment &amp; System Ratings/PL 84-99 Eligibility</b> <div> <div>Likely Prevents Performance In Next Flood Event</div> <div>Serious deficiency noted in past inspections has not been corrected within the established timeframe</div> <div>Likely Prevents Performance In Next Flood Event (Framework)</div> <div>Not Likely to Prevent Performance In Next Flood Event</div> <div>Not Likely to Prevent Performance In Next Flood Event (Framework)</div> </div> <div> <b>Legend</b>  A Acceptable  M Minimally Acceptable  U Unacceptable  N/A Not Applicable </div>								
The lowest rating is used to determine the overall segment & system ratings and PL 84-99 Rehabilitation Eligibility								July 6, 2010

**Table A-5. American River Flood Control District – American River Right Bank – Natomas East Main Drainage Canal System Report Card**

American River Right Bank, NEMDC Minimally Acceptable-Active	Unit 1, Arcade Creek Left Bank	Unit 2, South NEMDC below Arcade Creek	Unit 3, SRFCF American River Right Bank, MA 10 and 11					
Operations and Maintenance Manuals	M	M	M					
Emergency Supplies and Equipment	A	A	A					
Flood Preparedness and Training	A	A	A					
Unwanted Vegetation Growth	U	M	U					
Sod Cover	A	M	A					
Encroachments	U	U	U					
Closure Structures	A	N/A	A					
Slope Stability	A	M	A					
Erosion/Bank Caving	M	A	A					
Settlement	A	A	A					
Depressions/Rutting	A	A	A					
Cracking	A	A	A					
Animal Control	M	M	M					
Culverts/Discharge Pipes	N/A	N/A	N/A	U				
Riprap Revetments & Bank Protection	A	N/A	N/A	N/A				
Revetments other than Riprap	A	N/A	N/A	N/A				
Underseepage Relief Wells/Toe Drainage Systems	A	N/A	N/A	N/A				
Seepage	A	A	A	A				
<b>Segment &amp; System Ratings/PL 84-99 Eligibility</b> <div> <div>Likely Prevents Performance In Next Flood Event</div> <div>Serious deficiency noted in past inspections has not been corrected within the established timeframe</div> <div>Likely Prevents Performance In Next Flood Event (Framework)</div> <div>Not Likely to Prevent Performance In Next Flood Event</div> <div>Not Likely to Prevent Performance In Next Flood Event (Framework)</div> </div> <div> <b>Legend</b>  A Acceptable  M Minimally Acceptable  U Unacceptable  N/A Not Applicable </div>								
The lowest rating is used to determine the overall segment & system ratings and PL 84-99 Rehabilitation Eligibility								July 6, 2010



**Table A-6. Reclamation District 1000 – Natomas System Report Card**

RD 1000 - Natomas Unacceptable-Active	Unit 1, Sacramento River	Unit 2, American River	Unit 3 South, NEMDC	Unit 3 North, Cross Canal inflow	Unit 4, Natomas Cross Canal				
Operations and Maintenance Manuals	M	M	M	M	M				
Emergency Supplies and Equipment	A	A	A	A	A				
Flood Preparedness and Training	A	A	A	A	A				
Unwanted Vegetation Growth	U	U	U	U	U				
Sod Cover	A	A	A	A	A				
Encroachments	U	U	U	U	U				
Closure Structures	NA	NA	NA	NA	NA				
Slope Stability	M	A	M	A	M				
Erosion/Bank Caving	U	M	M	U	U				
Settlement	M	A	A	A	A				
Depressions/Rutting	A	A	M	M	A				
Cracking	M	A	M	A	A				
Animal Control	M	A	M	M	M				
Culverts/Discharge Pipes	NA	NA	NA	NA	NA				
Riprap Revetments & Bank Protection	M	NA	M	M	A				
Revetments other than Riprap	NA	NA	NA	NA	NA				
Underseepage Relief Wells/Toe Drainage Systems	NA	NA	NA	NA	NA				
Seepage	A	A	A	A	A				
<div> <div>Segment &amp; System Ratings/PL 84-99 Eligibility</div> <div> <div>Likely Prevents Performance in Next Flood Event</div> <div>Serious deficiency noted in past inspections has not been corrected within the established timeframe</div> <div>Likely Prevents Performance in Next Flood Event (Framework)</div> <div>Not Likely to Prevent Performance in Next Flood Event</div> <div>Not Likely to Prevent Performance in Next Flood Event (Framework)</div> </div> <div>The lowest rating is used to determine the overall segment &amp; system ratings and PL 84-99 Rehabilitation Eligibility</div> </div>									
						<b>Legend</b> A Acceptable M Minimally Acceptable U Unacceptable N/A Not Applicable			

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**Table A-7. Feather River Right Bank – Sutter Bypass East Bank  
Levee System Report Card**

Feather River Right Bank – Sutter Bypass East Bank Levee System Unacceptable-Inactive	Feather River – Hamilton West Levee – South of Alameda Outflow Dam	Maintenance Area 07	Reclamation District 777 Live Oak – Maintenance Area 16	Levee District 9 – Sutter County	Levee District 1 – Sutter County	Maintenance Area 03	Sutter Bypass East Levee – South of Wadsworth Canal	Wadsworth Canal – Unit 1, Left Bank	Interceptor Canal – Unit 1, East Canal
Operations and Maintenance Manuals	M	M	M	M	M	M	M	M	M
Emergency Supplies and Equipment	A	A	A	M	A	A	A	A	A
Flood Preparedness and Training	A	A	A	M	A	A	A	A	A
Unwanted Vegetation Growth	U	U	U	U	U	U	U	U	U
Sod Cover	N/A	M	M	M	M	M	M	M	A
Encroachments	U	U	U	U	U	U	U	U	U
Closure Structures	U	N/A	N/A	A	A	N/A	N/A	A	N/A
Slope Stability	M	U	A	U	M	M	M	A	M
Erosion/Bank Caving	A	U	U	U	U	U	U	U	U
Settlement	A	A	A	A	A	A	A	A	A
Depressions/Rutting	U	U	M	U	M	M	U	M	U
Cracking	A	A	A	A	A	A	A	A	A
Animal Control	A	M	M	M	M	M	M	M	M
Culverts/Discharge Pipes	N/A	N/A	N/A	N/A	N/A	U	N/A	N/A	N/A
Riprap Revetments & Bank Protection	N/A	M	N/A	N/A	M	M	N/A	N/A	N/A
Revetments other than Riprap	A	N/A	N/A	U	M	N/A	M	N/A	N/A
Underseepage Relief Wells/Toe Drainage Systems	N/A	N/A	N/A	N/A	U	N/A	N/A	N/A	N/A
Seepage	A	A	A	A	A	A	A	A	A
<div> <div>Segment &amp; System Ratings/PL 84-99 Eligibility</div> <div> <div>Likely Prevents Performance in Next Flood Event</div> <div>Serious deficiency noted in past inspections has not been corrected within the established timeframe</div> <div>Likely Prevents Performance in Next Flood Event (Framework)</div> <div>Not Likely to Prevent Performance in Next Flood Event</div> <div>Not Likely to Prevent Performance in Next Flood Event (Framework)</div> </div> <div>The lowest rating is used to determine the overall segment &amp; system ratings and PL 84-99 Rehabilitation Eligibility</div> </div>									
						<b>Legend</b> A Acceptable M Minimally Acceptable U Unacceptable N/A Not Applicable			

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**Table A-8. Maintenance Area 09 – City of Sacramento, American River Left Bank Levee System Report Card**

MA 09 - City of Sacramento, American River Left Bank Levee System Unacceptable-Active	ARFCD - Unit 4, American River Left Bank	ARFCD - Unit 5, Sacramento River	City of Sacramento	MA 09 - Sutterville Rd to Freport	MA 09 - Freport to Hood	MA 09 - Hood to Snodgrass Slough
Operations and Maintenance Manuals	M	M	M	M	A	A
Emergency Supplies and Equipment	A	A	A	A	A	A
Flood Preparedness and Training	A	A	A	A	A	A
Unwanted Vegetation Growth	U	U	U	U	U	U
Sod Cover	A	A	M	M	M	A
Encroachments	U	U	U	U	U	U
Closure Structures	N/A	N/A	N/A	N/A	N/A	N/A
Slope Stability	M	A	M	M	M	M
Erosion/Bank Caving	M	M	M	M	M	M
Settlement	A	A	A	A	A	A
Depressions/Rutting	M	A	A	M	A	A
Cracking	A	A	A	A	A	A
Animal Control	M	M	M	M	M	M
Culverts/Discharge Pipes	N/A	N/A	N/A	N/A	N/A	N/A
Riprap Revetments & Bank Protection	M	M	M	M	M	A
Revetments other than Riprap	N/A	N/A	M	M	N/A	N/A
Underseepage Relief Wells/Toe Drainage Systems	N/A	N/A	N/A	N/A	N/A	N/A
Seepage	A	A	A	A	U	A
Flood Wall	U	N/A	U	A	N/A	N/A
Segment & System Ratings/PL 84-99 Eligibility Likely Prevents Performance in Next Flood Event Serious deficiency noted in past inspections has not been corrected within the established timeframe Likely Prevents Performance in Next Flood Event (Framework) Not Likely to Prevent Performance in Next Flood Event Not Likely to Prevent Performance in Next Flood Event (Framework) The lowest rating is used to determine the overall segment & system ratings and PL 84-99 Rehabilitation Eligibility						
					<b>Legend</b> A Acceptable M Minimally Acceptable U Unacceptable N/A Not Applicable	

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**Table A-9. Reclamation District 404 and Duck Creek Right Bank – Boggs Tract System Report Card**

RD 404 and Duck Creek right bank - Boggs Tract Unacceptable-Inactive	RD 404 - Unit 1 San Joaquin River Right Bank	RD 404 - Unit 2, French Camp Walker Slough	Duck Creek - Walker Slough right bank
Operations and Maintenance Manuals	M	M	M
Emergency Supplies and Equipment	M	M	M
Flood Preparedness and Training	M	M	M
Unwanted Vegetation Growth	U	U	U
Sod Cover	N/A	N/A	N/A
Encroachments	U	U	U
Closure Structures	N/A	N/A	N/A
Slope Stability	U	U	M
Erosion/Bank Caving	U	U	M
Settlement	U	A	A
Depressions/Rutting	M	U	A
Cracking	A	A	A
Animal Control	U	U	M
Culverts/Discharge Pipes	N/A	N/A	N/A
Riprap Revetments & Bank Protection	U	N/A	M
Revetments other than Riprap	N/A	N/A	N/A
Underseepage Relief Wells/Toe Drainage Systems	N/A	N/A	N/A
Seepage	A	M	A
Segment & System Ratings/PL 84-99 Eligibility Likely Prevents Performance in Next Flood Event Serious deficiency noted in past inspections has not been corrected within the established timeframe Likely Prevents Performance in Next Flood Event (Framework) Not Likely to Prevent Performance in Next Flood Event Not Likely to Prevent Performance in Next Flood Event (Framework) The lowest rating is used to determine the overall segment & system ratings and PL 84-99 Rehabilitation Eligibility			
			<b>Legend</b> A Acceptable M Minimally Acceptable U Unacceptable N/A Not Applicable

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**Table A-10. Reclamation Districts 0017, 2094, 2075, 2064 San Joaquin River East System Report Card**

RD 0017, 2094, 2096, 2075, 2064 - SJ River East Unacceptable-Inactive	RD 0017 Unit 1	RD 0017 Unit 2	RD 2096	RD 2094 Unit 1	RD 2094 Unit 2	RD 2075	RD 2064 Unit 1	RD 2064 Unit 2
Operations and Maintenance Manuals	A	A	M	A	A	M	M	M
Emergency Supplies and Equipment	A	A	A	A	A	M	M	M
Flood Preparedness and Training	A	A	M	M	M	M	M	M
Unwanted Vegetation Growth	U	U	U	U	U	U	U	U
Sod Cover	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Encroachments	U	U	U	M	M	U	U	U
Closure Structures	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Slope Stability	A	M	A	A	A	A	A	M
Erosion/Bank Caving	M	U	A	A	A	M	M	U
Settlement	M	M	M	M	M	M	M	M
Depressions/Rutting	M	U	A	A	A	U	U	U
Cracking	A	A	A	A	A	A	A	A
Animal Control	M	M	M	A	A	M	M	M
Culverts/Discharge Pipes	N/A	N/A	U	N/A	N/A	N/A	N/A	N/A
Riprap Revetments & Bank Protection	N/A	A	N/A	N/A	N/A	A	A	N/A
Revetments other than Riprap	N/A	M	M	A	N/A	N/A	A	M
Underseepage Relief Wells/Toe Drainage Systems	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Seepage	M	A	A	A	A	A	A	A
Pump Station	N/A	N/A	U	N/A	N/A	N/A	N/A	N/A
<div> <div> Segment &amp; System Ratings/PL 84-99 Eligibility </div> <div> <div>Likely Prevents Performance in Next Flood Event</div> <div>Serious deficiency noted in past inspections has not been corrected within the established timeframe</div> <div>Likely Prevents Performance in Next Flood Event (Framework)</div> <div>Not Likely to Prevent Performance in Next Flood Event</div> <div>Not Likely to Prevent Performance in Next Flood Event (Framework)</div> </div> <div> <div>Legend</div> <div>A Acceptable</div> <div>M Minimally Acceptable</div> <div>U Unacceptable</div> <div>N/A Not Applicable</div> </div> </div>								
The lowest rating is used to determine the overall segment & system ratings and PL 84-99 Rehabilitation Eligibility								
July 6, 2010								

## Historical Levee Breaches and Overtopping

The California Department of Water Resources (DWR) Levee Evaluations Program collected and cataloged historical levee performance data pertinent to levee assessments in a document database. Data sources include existing levee-related data available from DWR and USACE, levee records available from State agencies, the California Levee Database, levee data obtained from local agencies, and interviews with representatives from local agencies, landowners, and DWR personnel. Data were collected on historical evidence of breaching and overtopping. For additional details on this data collection effort with respect to the Non-Urban Levee Evaluations (NULE) Project, see the *Geotechnical Assessment Report for the North NULE Study Area and South NULE Study Area* (DWR, 2011a and 2011b). The results of this data collection effort under the Urban Levee Evaluations (ULE) Project will be reported in Geotechnical Evaluation Reports being prepared for each individual study area. Figures A-1 and A-2 show historical levee breaches and failures in the Sacramento and San Joaquin river watersheds, respectively. Figures A-3 and A-4 show historical levee overtopping events in the Sacramento and San Joaquin river watersheds, respectively.

## Flood Control System Status Report

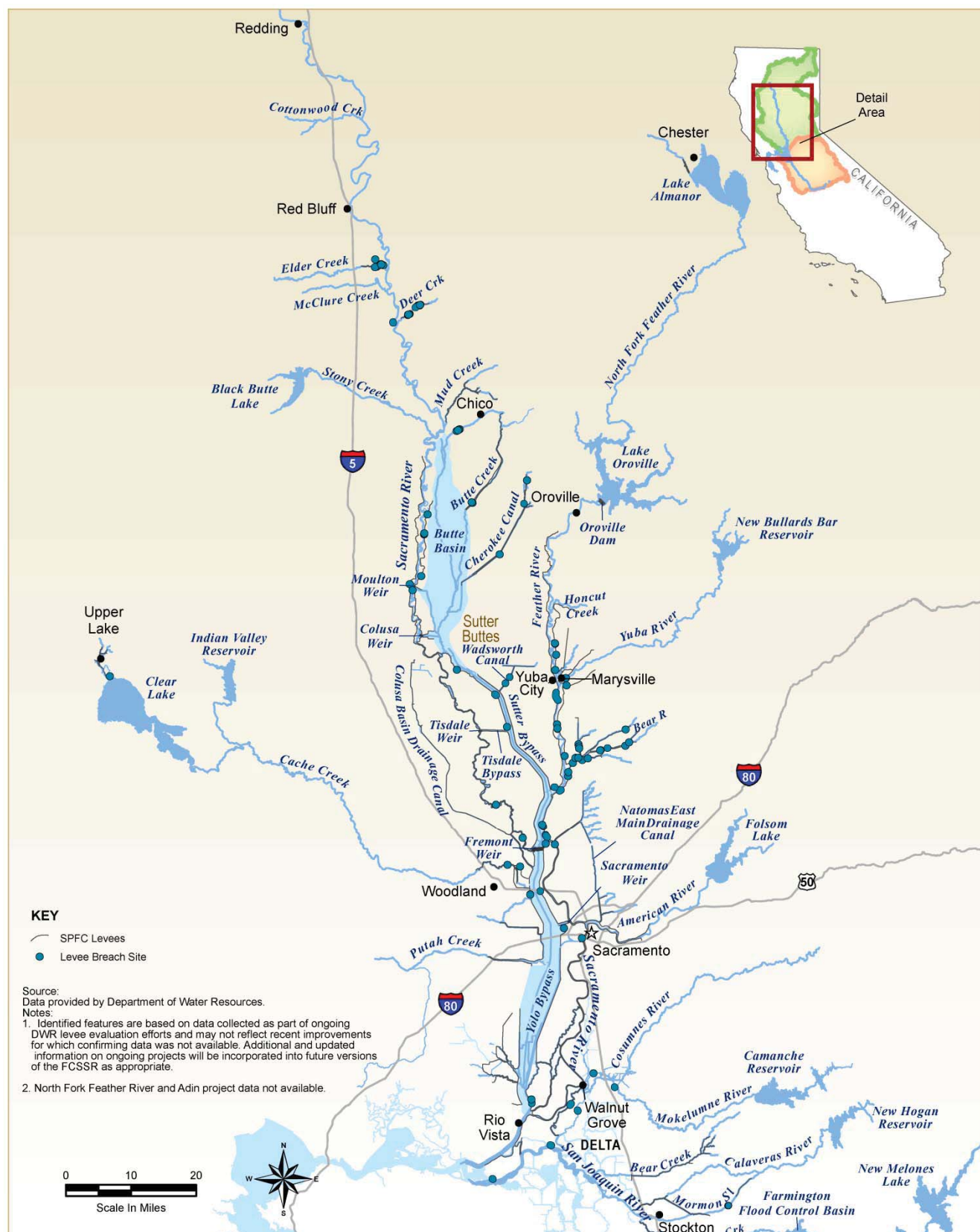


Figure A-1. Historical Levee Breaches in Sacramento River Watershed



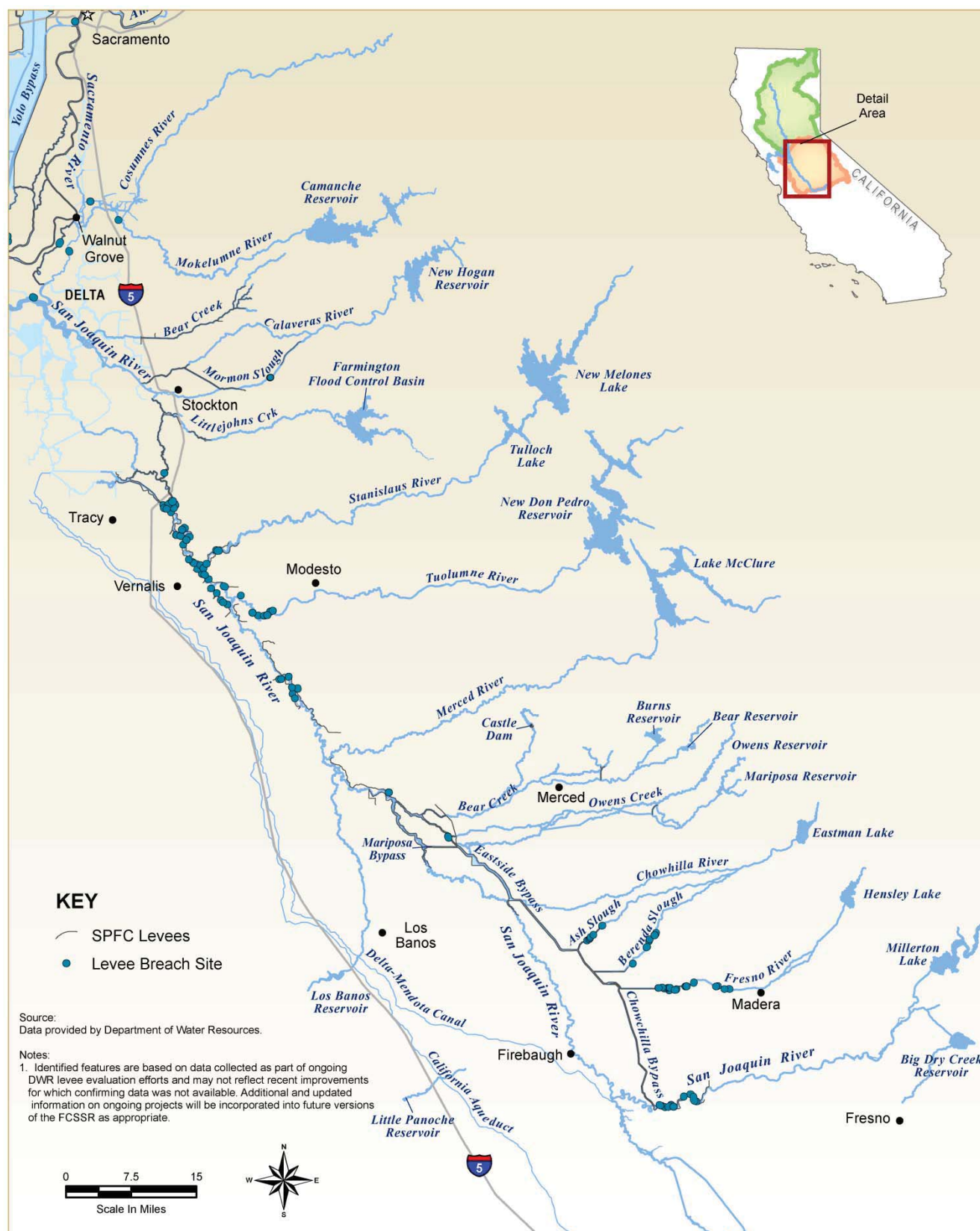
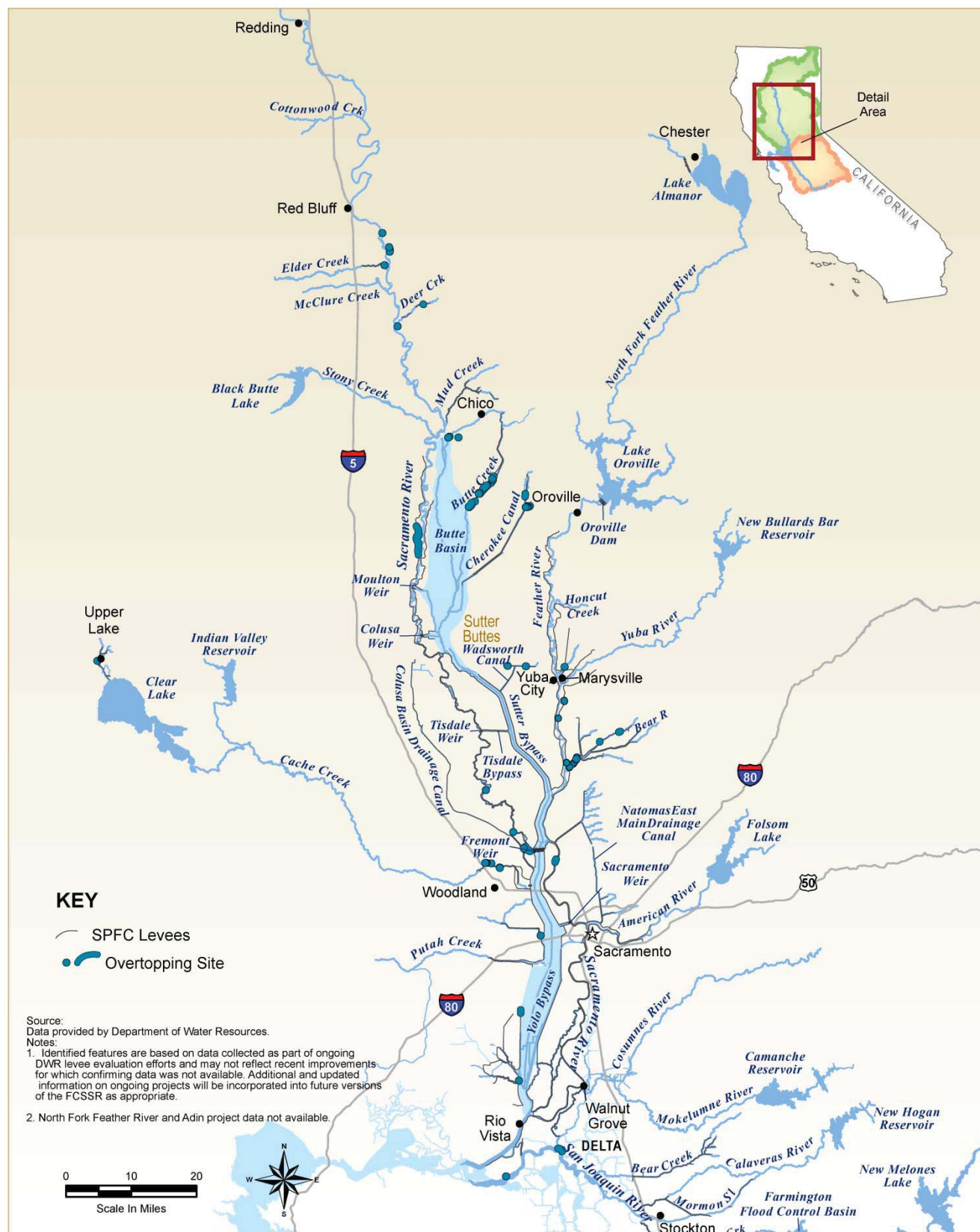


Figure A-2. Historical Levee Breaches in San Joaquin River Watershed

## Flood Control System Status Report



**Figure A-3. Historical Levee Overtopping in Sacramento River Watershed**

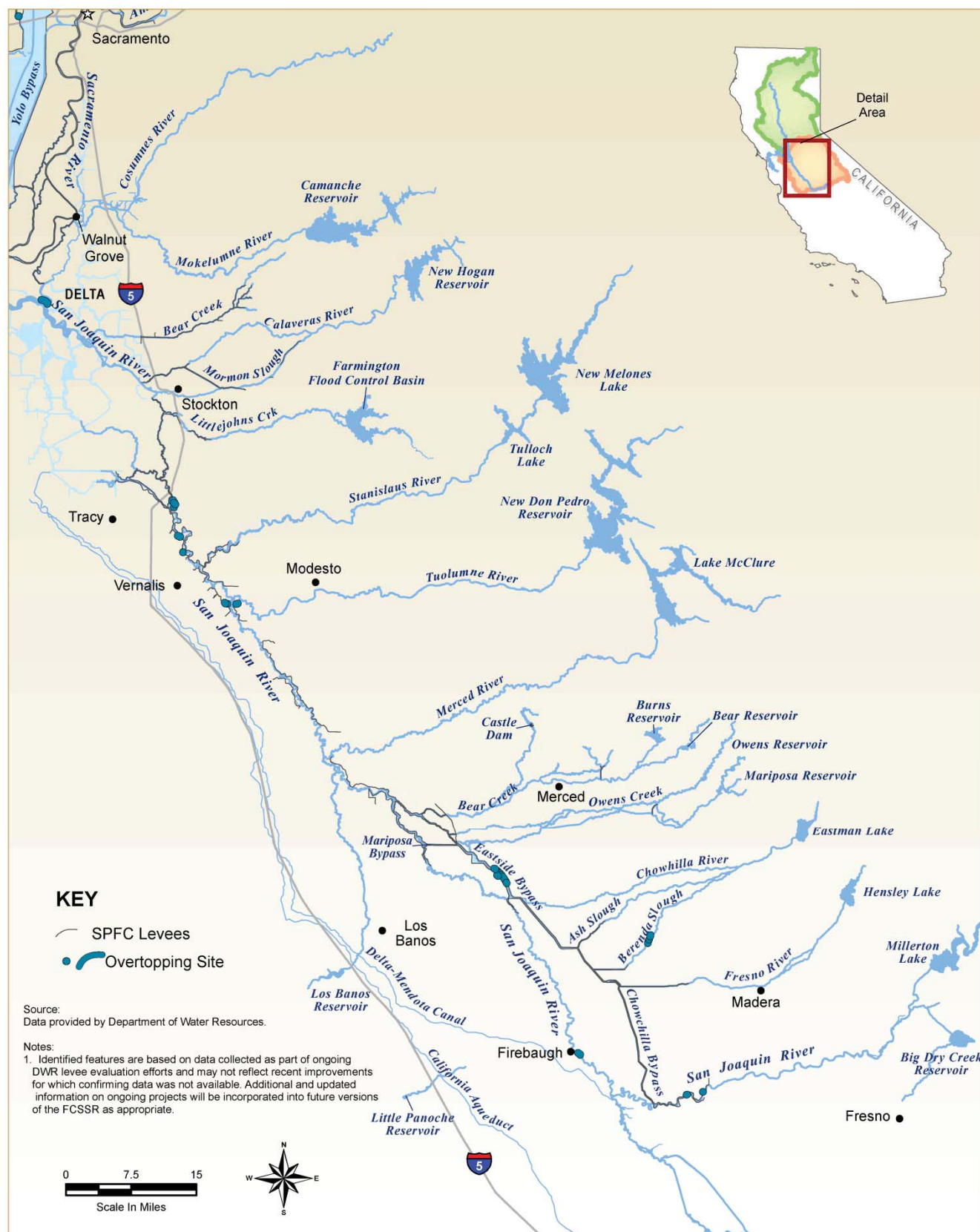


Figure A-4. Historical Levee Overtopping in San Joaquin River Watershed



### **Summary of Recent Remedial Actions/Improvements**

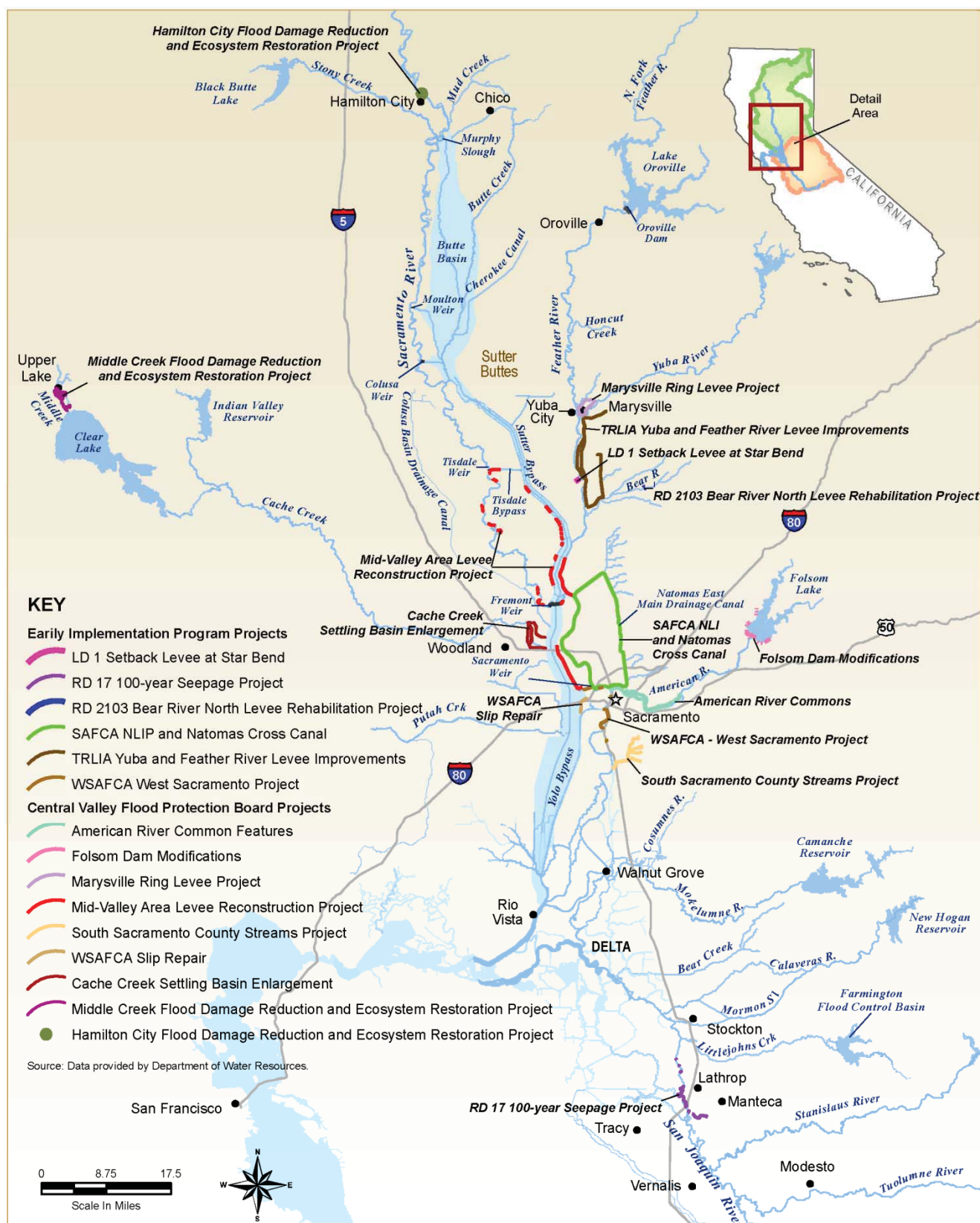
USACE, the Board, and local agencies continue to implement site-specific projects as they become ready for construction. The Early Implementation Program and USACE/Board projects are not part of the SPFC, but may become part of the SPFC after completion of the processes outlined in the *SPFC Descriptive Document*, Sections 7.6 and 7.7 (DWR, 2010a).

Locations of current Early Implementation Program and USACE/Board projects are shown in Figure A-5. Further description is included in the *SPFC Descriptive Document* (DWR, 2010a). Finally, other modifications to SPFC facilities have been completed by federal and local entities, but are not currently part of the SPFC because they lack State assurances of nonfederal cooperation to the federal government and/or State authorization.

#### ***Early Implementation Program***

From bond funds made available by Propositions 1E and 84, DWR has developed the Early Implementation Program to help local agencies to implement their projects in advance of adoption of the Central Valley Flood Protection Plan (CVFPP). Early Implementation Program projects have an identified benefit for proceeding before adoption of the 2012 CVFPP, especially if the Early Implementation Program project provides for increased level of protection for urban areas in deep floodplains. None of these projects have received Congressional authorization yet. A brief description of each project and its current status as of May 2011 is provided in Table A-11.





**Figure A-5. Early Implementation Program and USACE/Board Projects in Sacramento and San Joaquin River Watersheds**

**Table A-11. Early Implementation Program Project Summary**

<b>Project Name</b>	<b>Project Description</b>	<b>Project Status (May 2011)</b>
LD 1 Setback Levee at Star Bend (Feather River)	Setback levee with a cutoff wall and levee strengthening the existing levee system for the surrounding urban area.	Closeout phase
RD 17 100-Year Levee Seepage Area Project	Construction of cutoff walls, levee strengthening, seepage berms and setback levees to the existing system for the surrounding urban areas of South Stockton, Lathrop, and Manteca.	Construction phase
RD 2103 Bear River North Levee Rehabilitation Project	Construction of cutoff walls where under-seepage gradients on the landside toe exceed USACE criteria.	Closeout phase
SAFCA Natomas Levee Improvement Program (RD 1000)	Construction of cutoff walls and levee strengthening and reshaping features of the existing levee system surrounding the Natomas Basin.	Construction phase
TRLIA (RD 784) Feather River Levee Improvement Project	Construction of levee repairs and setback levees.	Closeout phase
TRLIA (RD 784) Upper Yuba Levee Improvement Project	Construction of levee repairs and setback levees.	Construction phase
WSAFCA West Sacramento Levee Improvement Project	Construction of levee improvements to achieve a 200-year level of protection.	Design phase

**Key:**

LD = levee district

RD = reclamation district

SAFCA = Sacramento Area Flood Control Agency

TRLIA = Three Rivers Levee Improvement Authority

USACE = U.S. Army Corps of Engineers

WSAFCA = West Sacramento Area Flood Control Agency

***USACE/Board Projects***

USACE, in partnership with the Board, is currently designing and constructing several projects that will improve the flood management system in the Sacramento and San Joaquin river watersheds. These projects reduce the occurrence and consequences of flooding. All USACE/Board projects have received Congressional authorization and have Board assurances of nonfederal cooperation contained in a project agreement. A listing and brief description of USACE/Board projects that are in design, construction, or closeout phases and their current status as of May 2011, is provided in Table A-12. In addition to the projects listed in Table A-12, several feasibility-level investigations are ongoing within the Sacramento and San Joaquin river watersheds. As these investigations

proceed toward specific projects and detailed design, construction, or closeout phases they will be included in future updates to the FCSSR.

**Table A-12. USACE/Board Project Summary**

Project Name	Project Description	Project Status (May 2011)
American River Watershed, Common Features Project	Raise and widen levees and close gaps in slurry walls to prevent flooding in the Sacramento area.	Construction and closeout phases
American River Watershed, Folsom Dam Joint Federal Project	Raise the dikes around Folsom Reservoir by 3.5 feet to increase surcharge flood storage.	Partially complete design phase
Hamilton City Flood Damage Reduction and Ecosystem Restoration Project	6.8-mile-long setback levee alignment that will increase the level of flood protection at Hamilton City and restore approximately 1,480 acres along the Sacramento River.	Design phase
Yuba River Basin Project, Marysville Ring Levee Element	Construction of cutoff walls and levee strengthening and reshaping features for the existing levee system surrounding the Marysville urban area.	Design phase
Middle Creek Flood Damage Reduction and Ecosystem Restoration Project	Construction of flow-regulation structures to restore vegetation and wetlands.	Design phase
South Sacramento County Streams Group Project	Construct channel improvements, floodwalls, levee raising, levees, seepage cutoff walls, and bridge retrofits.	Construction phase
West Sacramento Project (Slip Repair)	Levee raising, levee offsets, and slurry wall construction.	Construction phase
Cache Creek Settling Basin Enlargement	Enlargement of settling basin facilities.	Closeout phase
Sacramento River Bank Protection Project Phase II <sup>1</sup>	Bank protection at identified sites of the Sacramento River Flood Control Project.	Design, construction, and closeout phases for different sites

Note:

<sup>1</sup> Because these sites are scattered throughout the Sacramento River watershed and GIS information was not available, the sites are not included on Figure A-5.

Key:

USACE – U.S. Army Corps of Engineers

### ***Modifications to SPFC Facilities***

In addition to the Early Implementation Program and USACE/Board projects, modifications to SPFC facilities influence SPFC status, but some are not part of the SPFC because they lack State of California (State) assurances of cooperation to the federal government and/or are not yet

authorized by the Board for acceptance into the SPFC. Some modifications will not be authorized by the Board for acceptance into the SPFC, such as a gap in the Yolo Bypass east levee created by construction of the Sacramento Deep Water Ship Channel. The function of the previous levee was superseded by the Sacramento Deep Water Ship Channel federal navigation levee, but the navigation levee is not part of the SPFC. Other modifications to SPFC facilities were completed without State assurances of cooperation to the federal government and have not been authorized by the Board for acceptance into the SPFC, but may be authorized in the future. These modifications include the San Joaquin Area Flood Control Agency Flood Protection Restoration Project and the South Olivehurst Detention Basin Project improvements. While these and other modifications may not meet the legislative definition of the SPFC, they provide an important collective contribution to improve the function and status of SPFC facilities.

### **Ongoing Actions to Improve Future Evaluations**

Levee analyses conducted through the DWR Levee Evaluations Program consider both past and future (projected) performance of levees as they relate to levee geometry, seepage, stability, erosion, and settlement. To perform a detailed evaluation of the levee system's current condition, a wide range of critical levee properties is being studied, including the following:

- Geomorphology
- Historical events
- Levee topography
- Levee materials and construction
- Subsurface conditions
- Erosion conditions

### ***Traditional and Other Methods***

Much of the evaluation of the levees and their foundations is done by relatively straightforward geotechnical exploration methods (e.g., drilling) to collect soil samples, which are then analyzed to assess subsurface conditions. Cone penetrometer testing is also used to determine the composition and properties of subsurface soils. Looking closely at subsurface soil conditions—such as moisture, density, soil grain size distribution, and shear strength—helps identify potential problems or weaknesses in levees. In addition to the basic geotechnical evaluation program of drilling and boring to collect levee soil samples, other proven methods and innovative technologies are being used to develop a

comprehensive understanding of the levees' existing subsurface conditions, and identify which areas are most in need of critical improvements or repairs.

### ***Light Detection and Ranging Surveys***

Light Detection and Ranging (LiDAR) technology deployed in low-flying helicopters has been used to electronically gather data about the topography and configuration of flood control levees. Results aid evaluation of levee geometry, stability, erosion, and settlement of the surveyed levees.

### ***Bathymetric Surveys***

The above-water topographic data collected during LiDAR surveys have been supplemented with bathymetric surveys. Underwater bathymetric surveys produce detailed topographic data of a riverbed and riverbanks that essentially form the base of the levee systems. The collected data provide an image of the levees' underwater structure that cannot be obtained by conventional land topographic methods. The results aid evaluation of levee geometry and erosion.

### ***Surficial Geomorphic Mapping***

A comprehensive surficial geomorphic map of project areas, based on field reconnaissance and review of vintage aerial photos and topographic maps, geologic maps, and satellite imagery, is also being prepared. Results of this effort will lead to a better understanding of the materials directly beneath existing levees and of geomorphic processes, such as erosion and deposition that are responsible for those materials. The collected data will aid evaluation of erosion, seepage, and structural instability.

### ***Electromagnetic Surveys***

Levee subsurface conditions are being evaluated by conducting geophysical electromagnetic surveys. The electromagnetic technology senses variations in the ground's electrical conductivity to depths of more than 100 feet underground. The goal is to map important changes in soil types and ground conditions, identifying zones where permeable soils are present or excessive water penetration is taking place. The results aid in evaluation of levee seepage, structural instability, erosion, and settlement.

## **A-2 Levee Geometry Check**

This section describes ULE and NULE freeboard check results, recent remedial actions/improvements (including locations of levee raises, widening, and levee reconstructions), current and ongoing remedial actions/improvements, and ongoing actions to improve future evaluations of levee geometry.



### Freeboard Check Results

Lack of levee freeboard can be caused by a variety of factors, such as settlement and inadequate maintenance. A freeboard check was conducted as part of the ULE and NULE projects. For the Sacramento River watershed, the freeboard check consisted of a comparison of the levee crest elevation, as provided by the levee crest survey data from the California Levee Database, to requirements of the *1953 Memorandum of Understanding* (USACE and Reclamation Board, 1953). The *1953 Memorandum of Understanding* generally requires a minimum of 3 feet of freeboard above the 1955/1957 design water surface elevation for riverine levees and 6 feet of freeboard above the 1955/1957 design water surface elevation for bypass levees.

For the San Joaquin River watershed, the freeboard check consisted of a comparison of the levee crest elevation with the design water surface elevation. Freeboard requirements were indicated from available design data. If a levee segment lacked a verifiable design water surface elevation but a 1 percent chance event (100-year) water surface elevation was available, it was used to assess freeboard. Such conditions were specific to the Calaveras and Bear Creek systems in San Joaquin County. Where neither a design nor 1 percent chance event water surface elevation were available, the freeboard check could not be performed.

### Urban Levee Evaluations Project

ULE Project evaluations included assessing each ULE levee segment and assigning each segment to one of the following classifications:

- **Meets Criteria (M)** – Levees in this classification meet or exceed criteria.
- **Marginal (MG)** – Levees in this classification are marginal in meeting criteria.
- **Does Not Meet Criteria (DNM)** – Levees in this classification do not meet criteria. These are the levees that require the most immediate attention for repair or replacement.
- **Lacking Sufficient Data (LD)** – Levees in this classification lack sufficient data to allow placement into one of the above three classifications.

ULE freeboard check results are shown on Figure A-6. Levees that do not meet freeboard criteria include portions of the Pleasant Grove Creek Canal and Natomas East Main Drainage Canal, the south bank of the Yuba River east of Marysville, the Davis/Woodland area and along Upper Bear Creek.

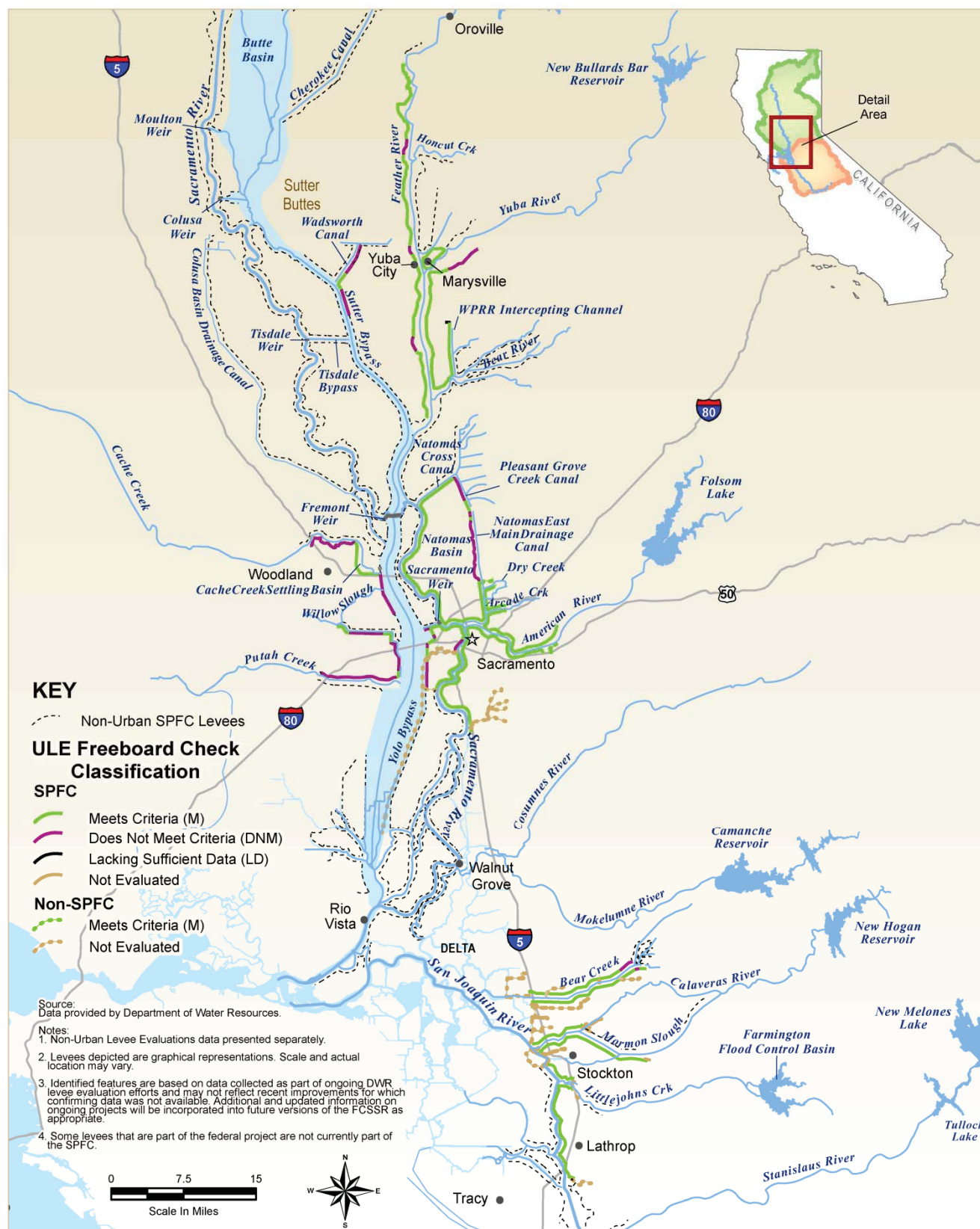


Figure A-6. ULE Freeboard Check Results

### ***Non-Urban Levee Evaluations Project***

Figures A-7 and A-8 show a pass or fail result for NULE levee segments in both the Sacramento and San Joaquin river watersheds regarding whether they meet freeboard requirements. Freeboard results show that portions of both banks of the Sutter Bypass, both banks of the Yolo Bypass, Butte Creek, Colusa Basin Drainage Canal, and the Bear River do not meet freeboard criteria. Compliance with freeboard criteria is variable in other areas within the Sacramento River watershed. In the San Joaquin River watershed, levee reaches along the lower Stanislaus River, lower Tuolumne River, San Joaquin River downstream of Merced River, upper Bear Creek and Paddy Creek do not meet freeboard criteria.

For additional details on the NULE freeboard check methodology and results, see the *Geotechnical Assessment Report for the North NULE Study Area and South NULE Study Area* (DWR, 2011a and 2011b).



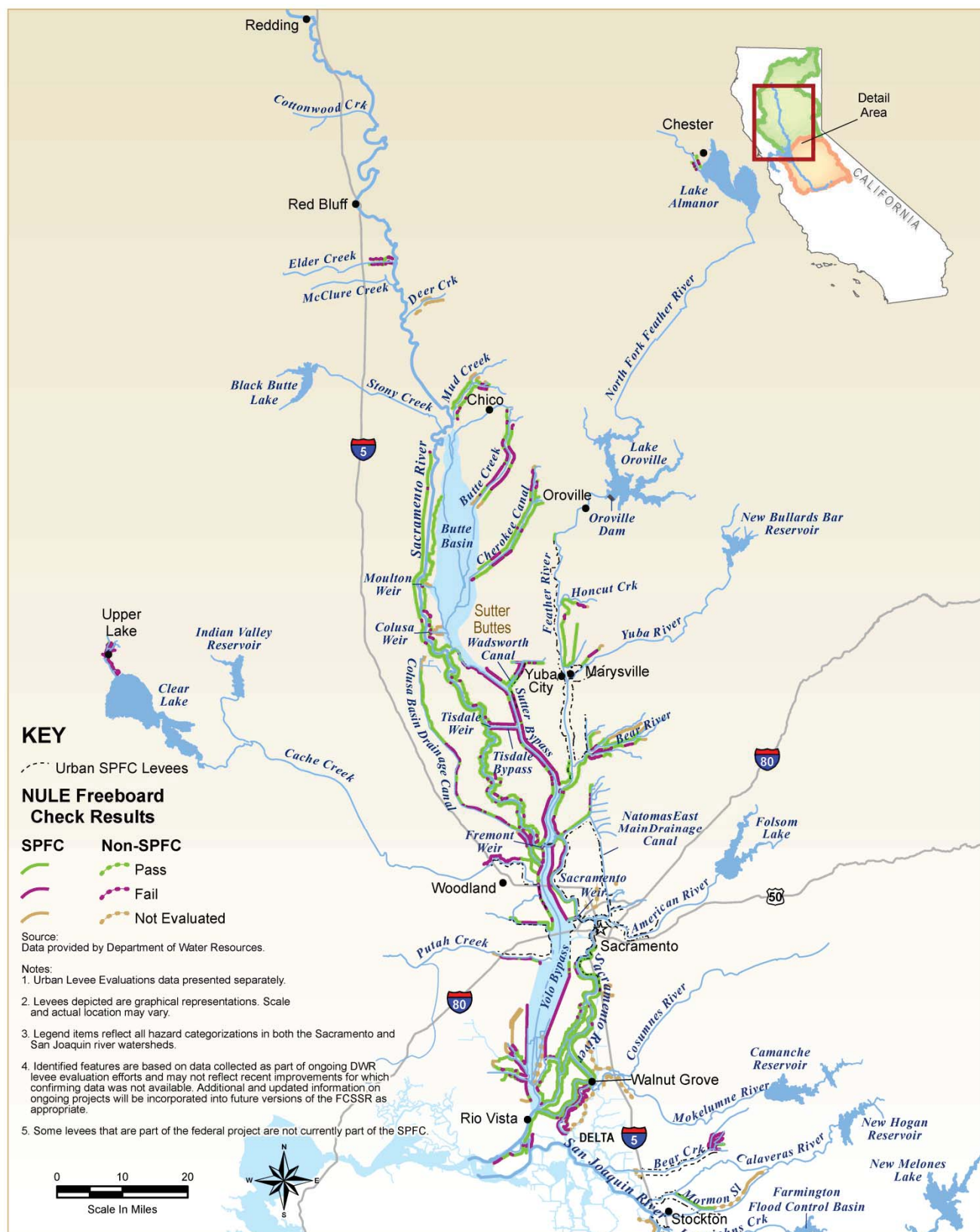


Figure A-7. NULE Freeboard Check Results in Sacramento River Watershed

## Flood Control System Status Report

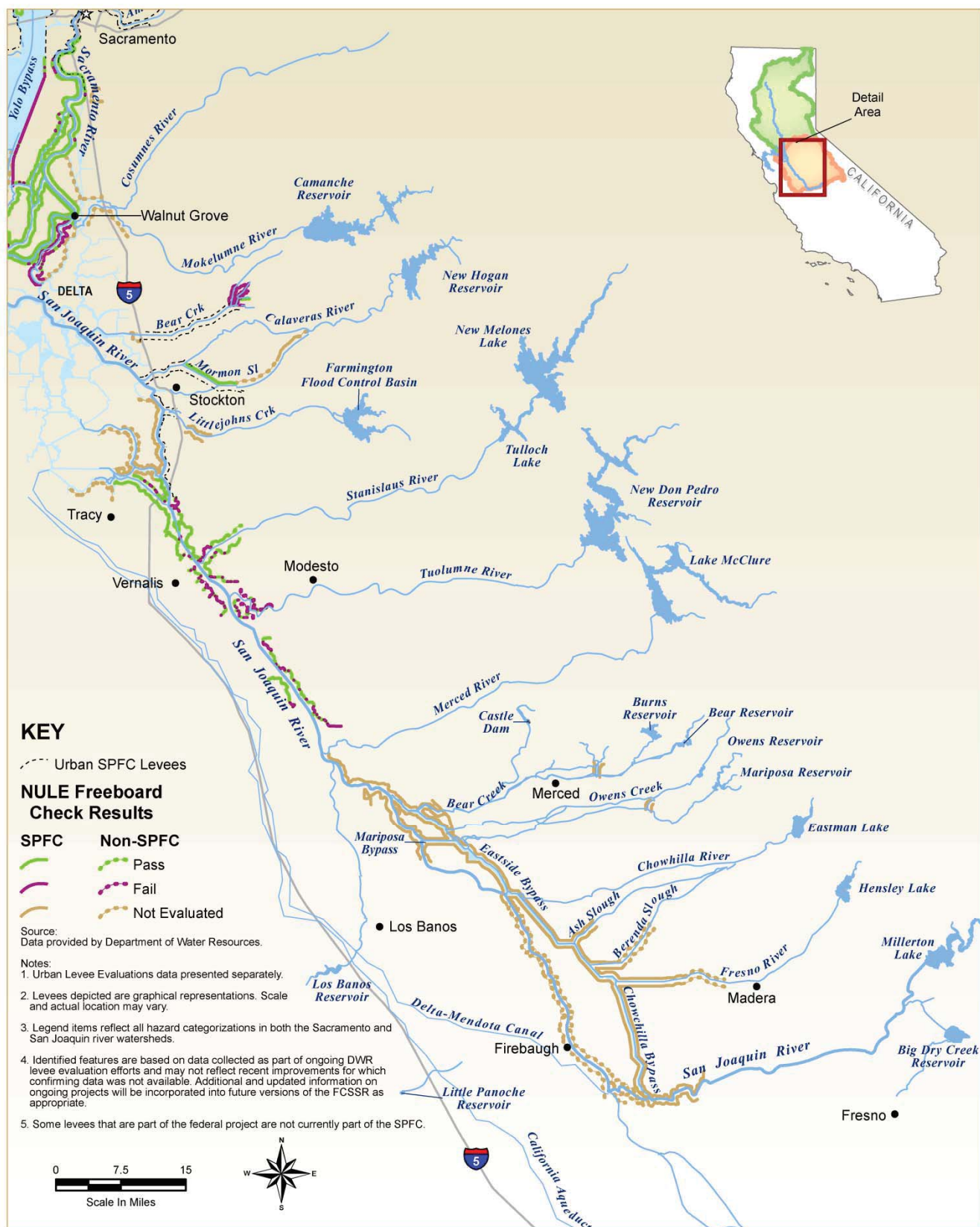


Figure A-8. NULE Freeboard Check Results in San Joaquin River Watershed

### **Summary of Recent Remedial Actions/Improvements**

DWR's Levee Evaluations Program collected and cataloged recent levee raises, levee widening, and levee reconstructions. Figures A-9 and A-10 show locations of these documented reconstructions and improvements for the Sacramento River and San Joaquin River watersheds, respectively.

### **Summary of Ongoing and Planned Remedial Actions/Improvements**

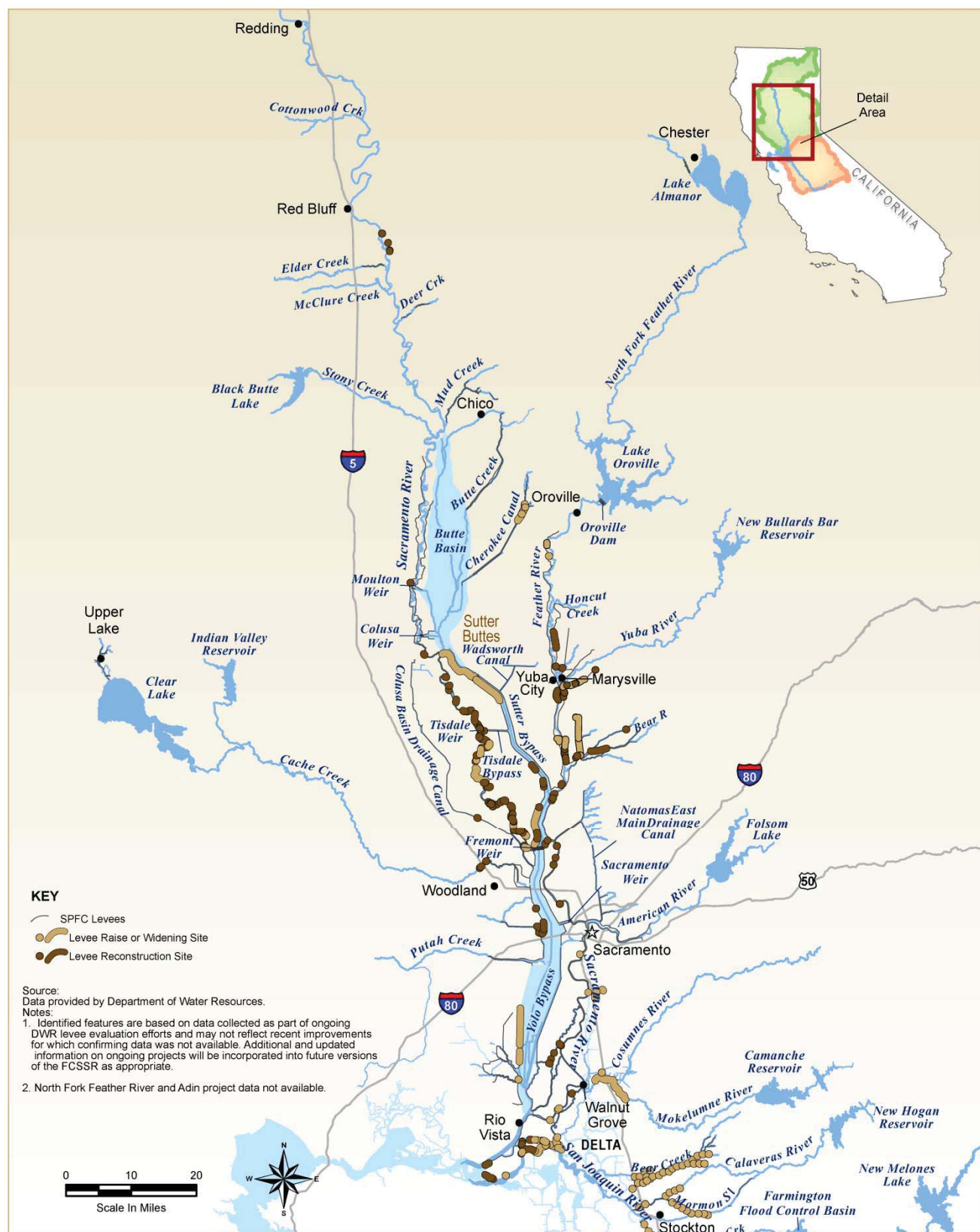
Several of the Early Implementation Program and USACE/Board projects discussed in Section A-1 include levee reconstructions and improvements that address inadequate levee geometry.

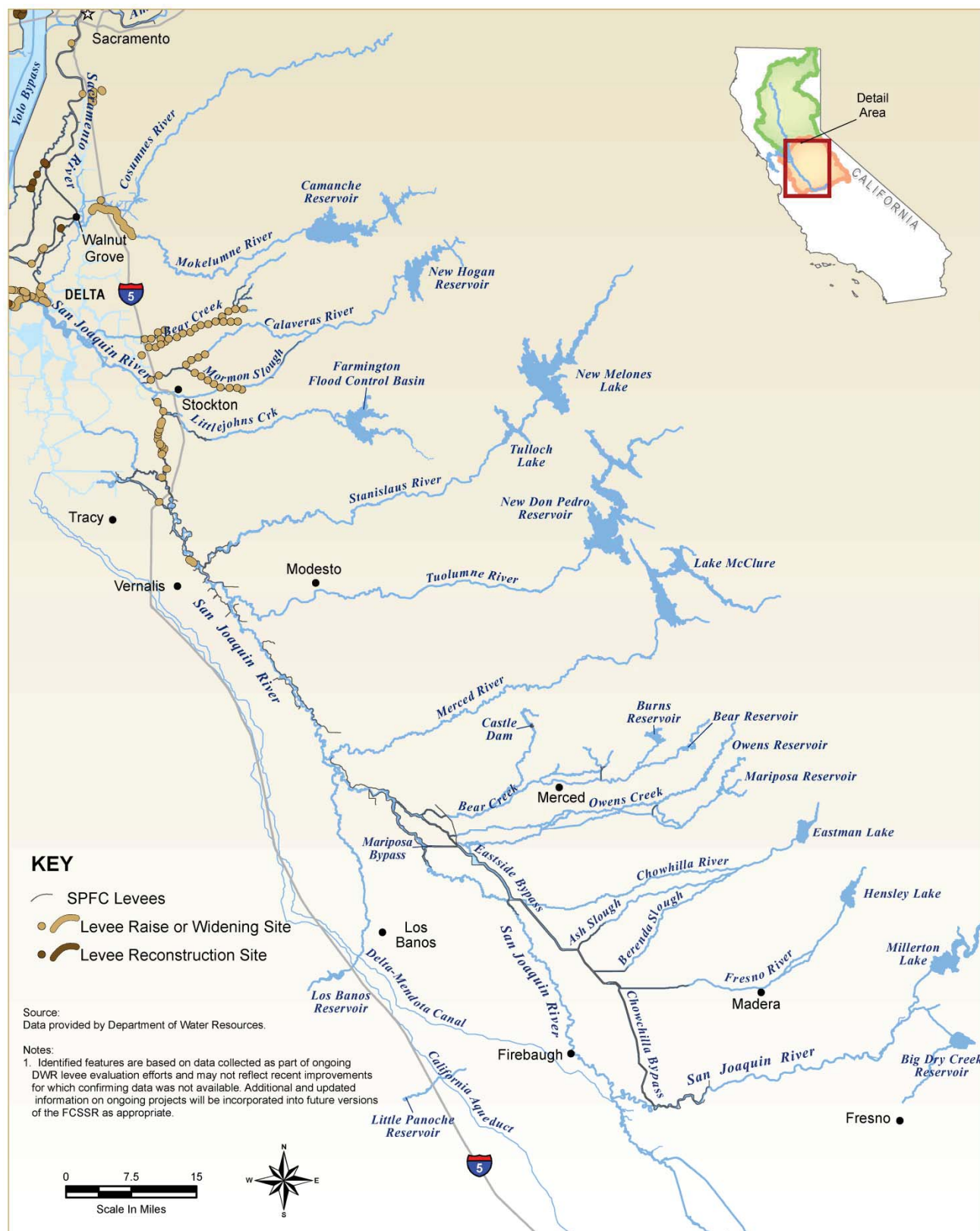
### **Ongoing Actions to Improve Future Evaluations**

DWR continues to collect levee information using traditional and innovative methods, including LiDAR and bathymetric surveys (see Section A-1).



## Flood Control System Status Report





**Figure A-10. Levee Raises, Levee Widenings, and Levee Reconstructions in San Joaquin River Watershed**

### A-3 Seepage

This section includes DWR annual inspection results for seepage, and locations of historical seepage occurrences documented by the ULE and NULE projects. Recent, current, and ongoing remedial actions/improvements including locations of seepage remediation projects documented by the ULE and NULE projects, and seepage-related levee reconstructions and improvements planned and conducted by DWR, are described. A description of ongoing actions to improve future evaluations is also included.

#### Results of Inspections

DWR visually inspects SPFC levees for seepage/sand boils at least twice a year, and reports results annually. Table A-13 shows the DWR inspection rating descriptions for seepage/sand boils on earthen levees.

**Table A-13. Levee Inspection Rating Descriptions for Seepage/Sand Boils on Earthen Levees**

Inspection Rating	Rating Descriptions
Acceptable (A)	No seepage, saturated areas, or sand boils occurring at the time of the inspection.
Unacceptable (U)	Seepage and/or sand boils were observed that could threaten the integrity of the project. Regardless of size, any sand boils observed during low water conditions could threaten project integrity when the water is high, and are considered unacceptable.

The biannual inspections that DWR conducts are performed during the spring and fall of each year, and do not necessarily coincide with the flood season. Therefore, routine DWR inspections are less likely to reveal instances of seepage because inspections are usually performed when water is below the toe of levees. Furthermore, the extent of seepage and whether the seepage condition is in a steady or changing state are difficult to determine from visual inspections. Limited knowledge of subsurface conditions also makes it difficult to identify seepage problems.

Because 2009 was a relatively dry year and there were no high-water events, no occurrences of seepage/sand boils were observed or documented in the *2009 Inspection Report of the Central Valley State-Federal Flood Protection System* (DWR, 2010b).

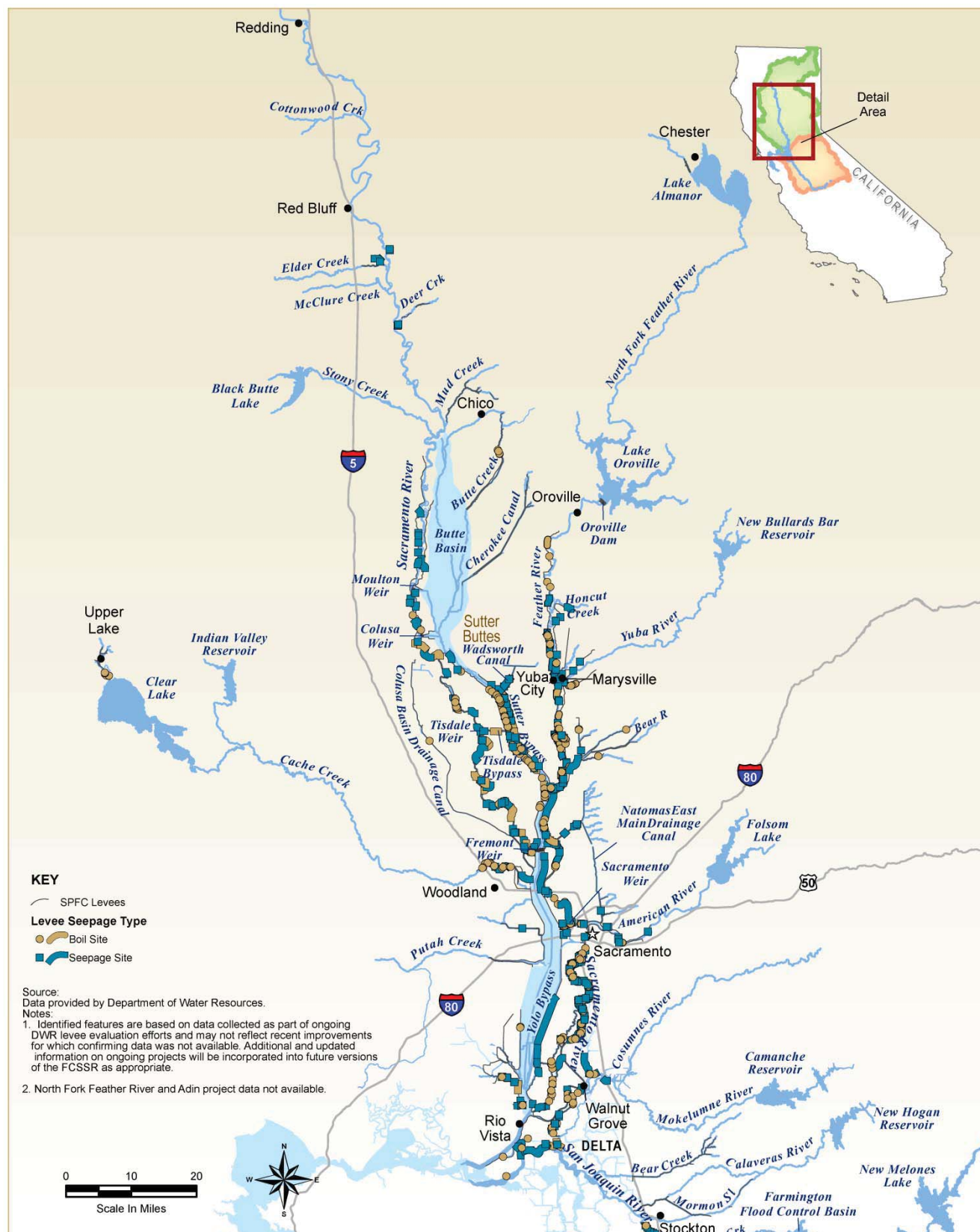
#### Historical Seepage Occurrences

The ULE and NULE projects collected and cataloged historical occurrences of levee seepage and completed or planned repairs or

improvements. Figures A-11 and A-12 show historical seepage occurrences collected by the ULE and NULE projects in the Sacramento and San Joaquin river watersheds, respectively. In the Sacramento River watershed, historical seepage occurrences were located throughout the system and were particularly prevalent along the Sutter Bypass and Sacramento River south of Sacramento. In the San Joaquin River watershed, most historical seepage occurrences were along the San Joaquin River and Eastside Bypass.



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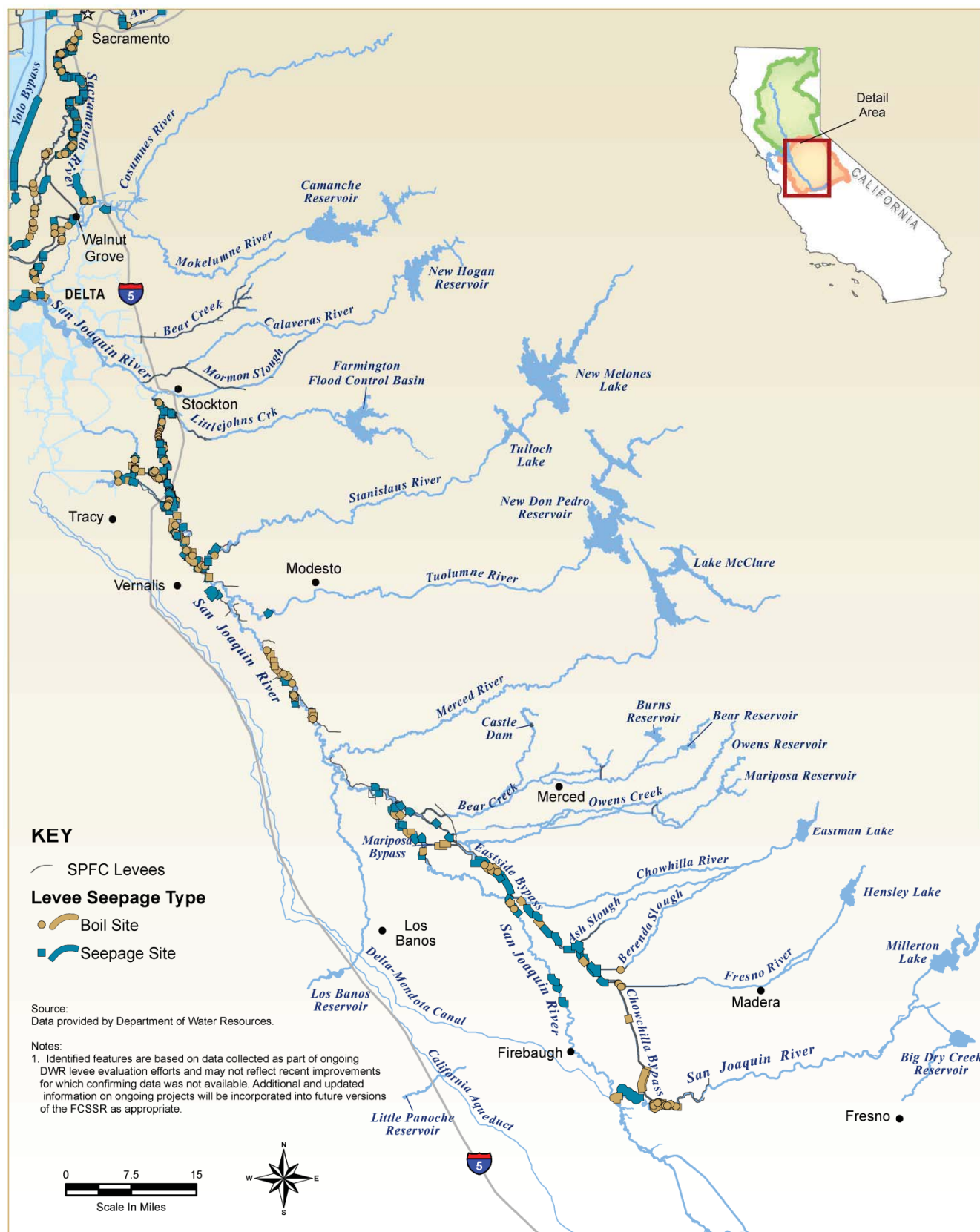


Figure A-12. Historical Seepage Occurrences in San Joaquin River Watershed

### **Summary of Recent Remedial Actions**

Seepage remediation projects have been constructed throughout the Sacramento and San Joaquin river watersheds to address identified seepage problems. The ULE and NULE projects collected and cataloged data on the locations of a wide range of seepage remediation actions. Figures A-13 and A-14 show seepage remediation efforts in the Sacramento River and San Joaquin River watersheds, respectively. Seepage remediation has occurred throughout the Sacramento River watershed and is particularly concentrated in the Sutter Bypass, lower Feather River, west side of Natomas, American River, Sacramento River south of Sacramento, and Yolo Bypass near Woodland. In the San Joaquin River watershed, seepage remediation is the most concentrated on the lower San Joaquin River north of Stanislaus River and the upper San Joaquin River near the Chowchilla Bypass.

### **Summary of Ongoing and Planned Remedial Actions/Improvements**

Seepage and boils are identified and monitored by maintaining agencies to initiate floodfighting and levee reconstruction and/or improvements. DWR's Levee Repairs Program is described below, and many of the Early Implementation Program and USACE/Board projects identified in Section A-1 will preserve and enhance the integrity of SPFC levees with regard to seepage.

#### ***DWR Levee Repairs Program***

DWR's Levee Repairs Program repairs critically and not critically damaged levees. The projects are implemented through collaboration with the resource agencies, USACE, and local agencies. The Levee Stability Program and Public Law 84-99 Rehabilitation Assistance Program address seepage problems.

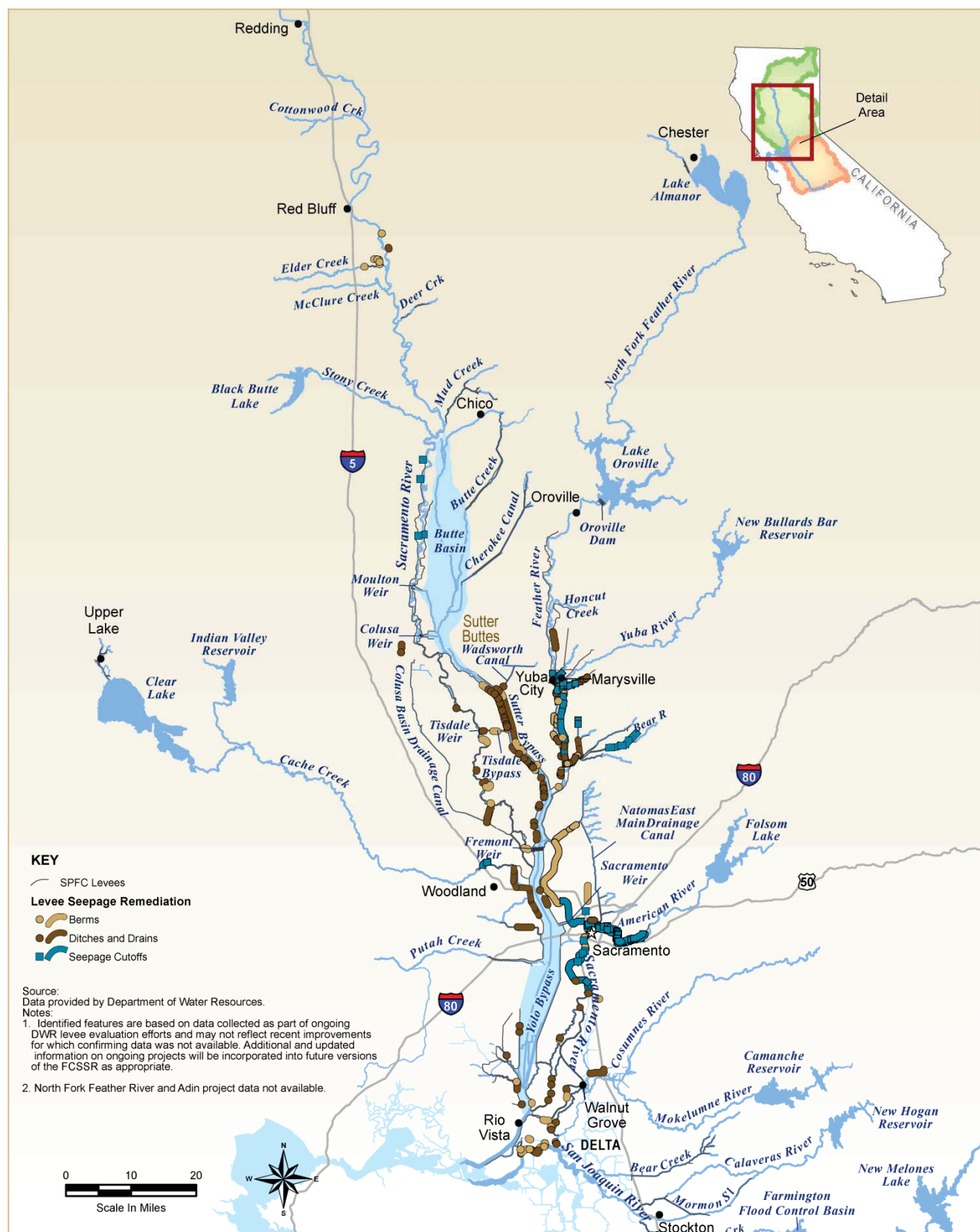
USACE's Levee Stability Program was authorized by the Water Resources Development Act of 2007. Levee Stability Program sites are selected by DWR's Levee Evaluations Program. As of December 2010, four seepage sites were recommended for remediation, but additional sites are anticipated as the Levee Evaluations Program continues.

The Flood Control and Coastal Emergency Act (Public Law 84-99) provides the federal government authority for emergency management activities. Under Public Law 84-99, USACE is authorized to undertake rehabilitation of flood control works threatened or destroyed by floods. USACE decides which sites qualify for assistance under the Public Law 84-99 program. After the 2005 – 2006 storms, 20 seepage sites were

determined to be eligible for Public Law 84-99 assistance by USACE. Since then, all of these sites have been rehabilitated.

Planned and completed seepage remediation sites from the Levee Stability Program and Public Law 84-99 program are shown in Figures A-15 and A-16 for the Sacramento River watershed and San Joaquin River watershed, respectively.

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**Figure A-13. Seepage Remediation in Sacramento River Watershed**



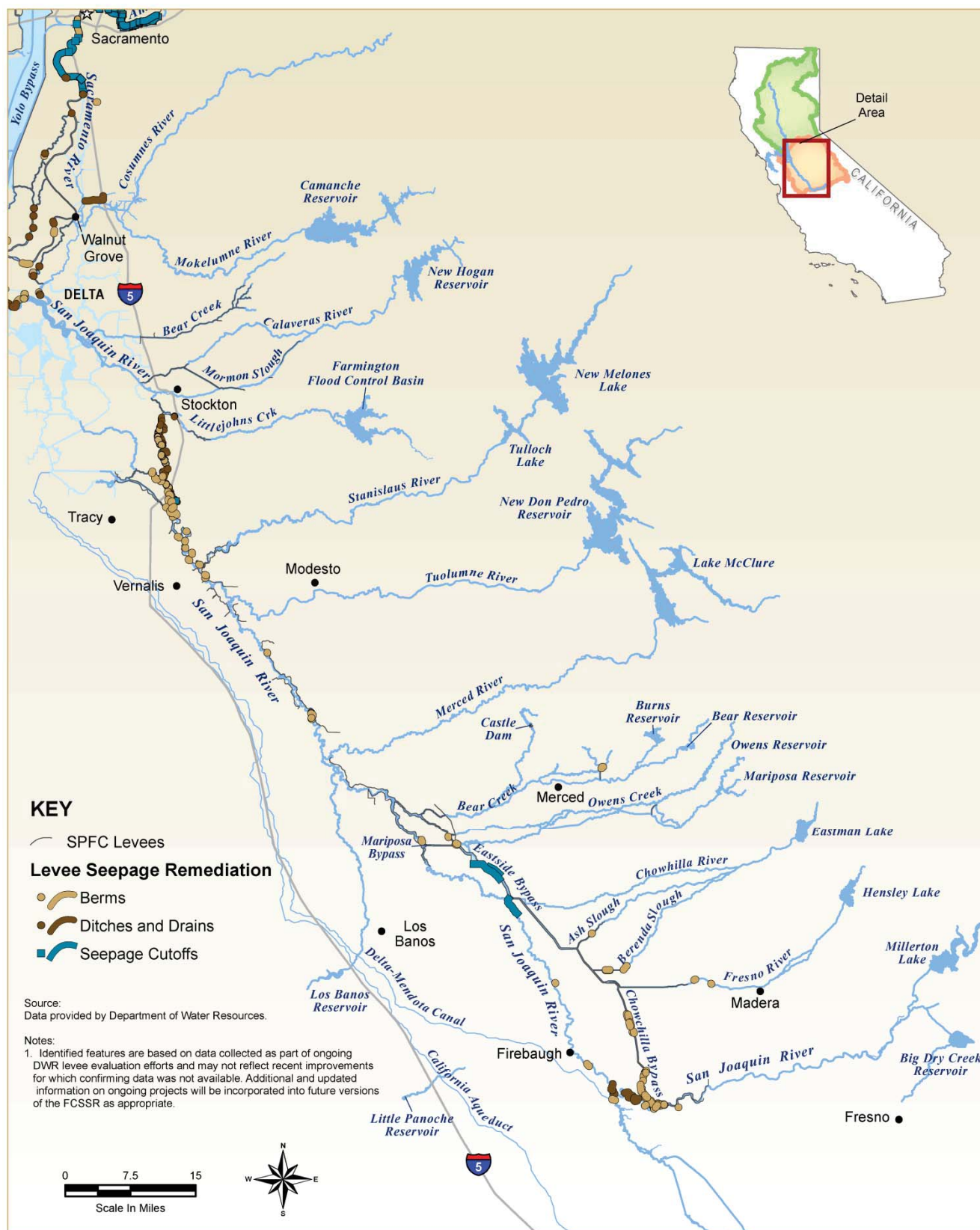
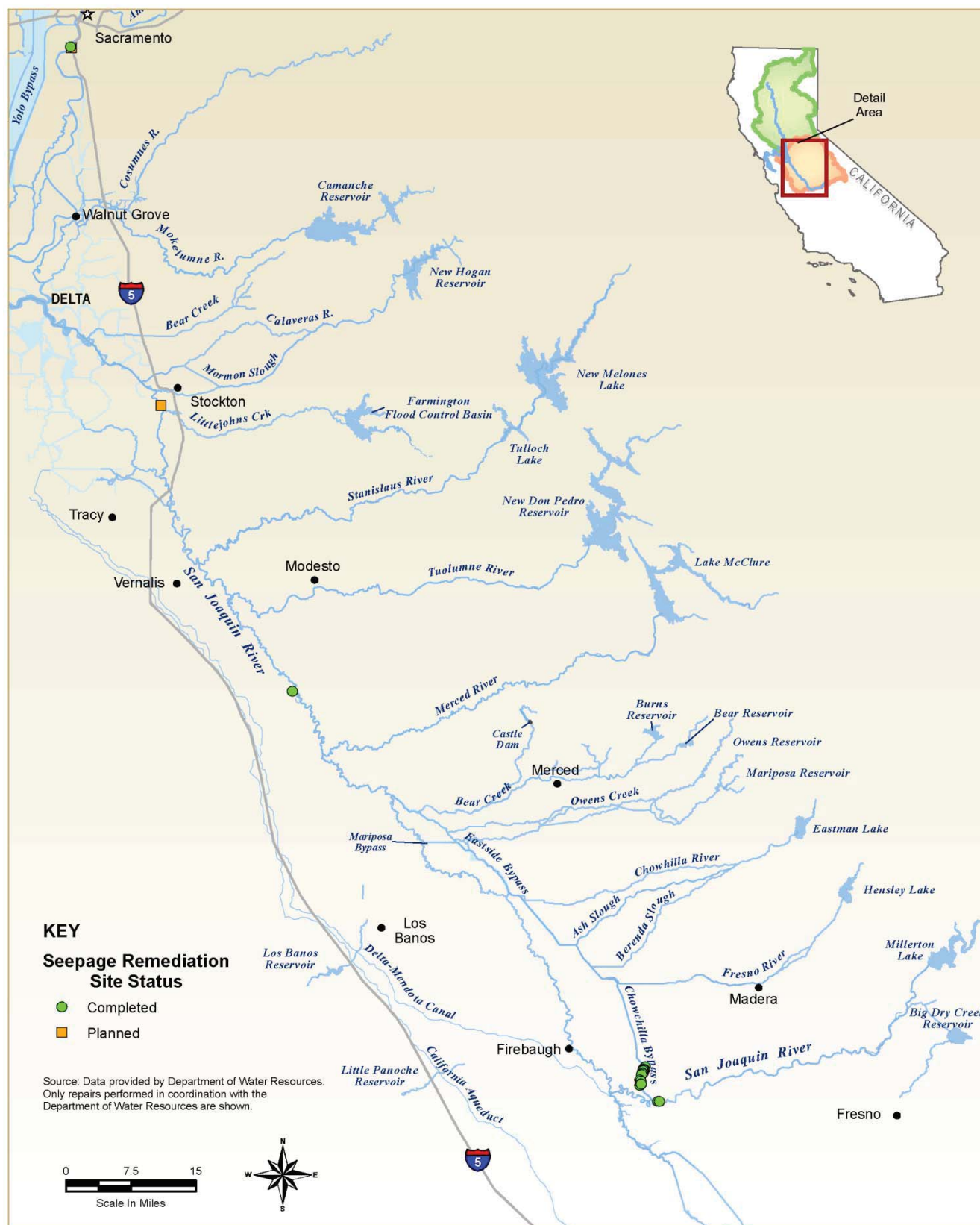


Figure A-14. Seepage Remediation in San Joaquin River Watershed

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**Figure A-15. Planned and Completed Seepage Remediation Sites from DWR Levee Stability Program and Public Law 84-99 Program in Sacramento River Watershed**



**Figure A-16. Planned and Completed Seepage Remediation Sites from DWR Levee Stability Program and Public Law 84-99 Program in San Joaquin River Watershed**



### Ongoing Actions to Improve Future Evaluations

DWR continues to collect levee information using traditional and new innovative methods, including electromagnetic surveys. DWR is also in the early planning stages of conducting a levee monitoring pilot study that would evaluate the effectiveness and usefulness of direct, real-time measurements of seepage rates through and under levees during high-water events. The study would involve installing sealed piezometers and river stage gages at preselected critical locations within the Sacramento and San Joaquin river watersheds.

## A-4 Structural Instability

This section includes results of the DWR annual inspections for slope stability and historical levee slope instability occurrences. Recent, ongoing, and planned remedial actions and improvements, and ongoing actions to improve future evaluations for structural instability are also included.

### Results of Inspections

As mentioned, DWR visually inspects SPFC levees at least twice a year, and reports results annually. Information is collected during the inspections on the performance of the levee embankment as it relates to slope stability. Table A-14 shows the DWR inspection rating descriptions for slope stability on earthen levees.

**Table A-14. Levee Inspection Rating Descriptions for Slope Stability on Earthen Levees**

Inspection Rating	Rating Descriptions
Acceptable (A)	No slides present.
Minimally Acceptable (M)	Minor superficial sliding that with deferred repairs will not pose an immediate threat to flood control works integrity.
Unacceptable (U)	Evidence of deep-seated sliding that threatens flood control works integrity. Repairs are required to reestablish flood control works integrity.

Visual inspections provide limited information on levee conditions related to slope stability. A typical levee inspection occurs from the crown of the levee. Thick vegetation and wide berms can obstruct an inspector's view of slides. Limited knowledge of subsurface conditions also makes it difficult to identify some slope stability problems.

Slope stability levee inspection ratings from the *2009 Inspection Report of the Central Valley State-Federal Flood Protection System* (DWR, 2010b)

are shown on Figures A-17 and A-18. Two sites with Unacceptable ratings for slope stability are located in the Delta. In the Sacramento River watershed has no Unacceptable ratings, but several sites, in various locations, have Minimally Acceptable ratings. In the San Joaquin River, Minimally Acceptable ratings are located on the lower San Joaquin River, Bear Creek, Mormon Slough, and Littlejohns Creek.

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**Figure A-17. 2009 Slope Stability Inspection Ratings in Sacramento River Watershed**



Figure A-18. 2009 Slope Stability Inspection Ratings in San Joaquin River Watershed

### **Historical Levee Slope Instability Occurrences**

The ULE and NULE projects collected and cataloged information on historical occurrences of levee slope instability. Figures A-19 and A-20 show historical slope instability occurrences collected from the ULE and NULE projects for the Sacramento and San Joaquin river watersheds, respectively. In the Sacramento River watershed, historical levee slope instability occurrences were located most frequently in the lower Sacramento River watershed south of the Fremont Weir. Slope instability was most prevalent on the Sacramento River south of Sacramento and in the north Delta. In the San Joaquin River watershed, historical levee slope instability occurrences were prevalent through the watershed.



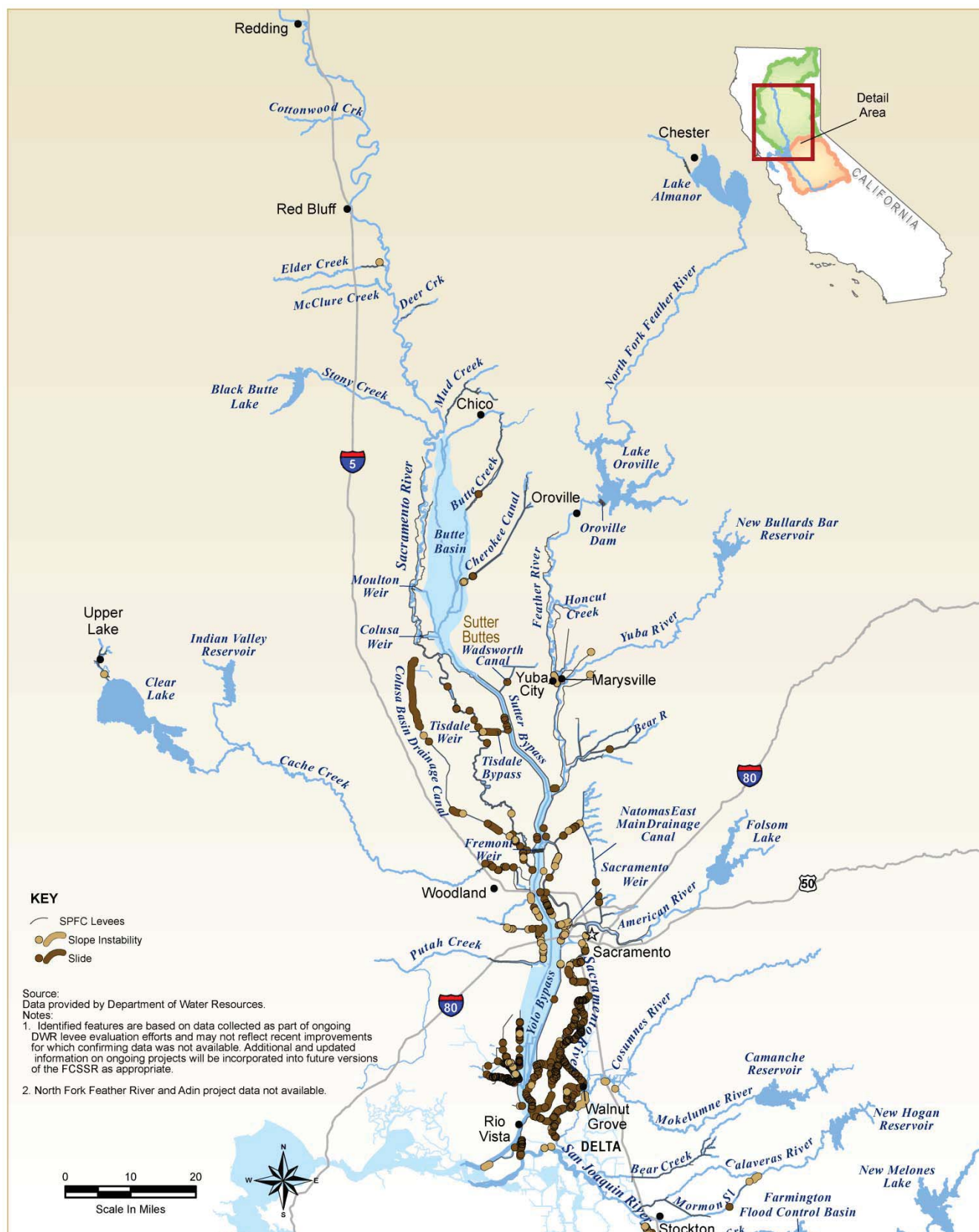
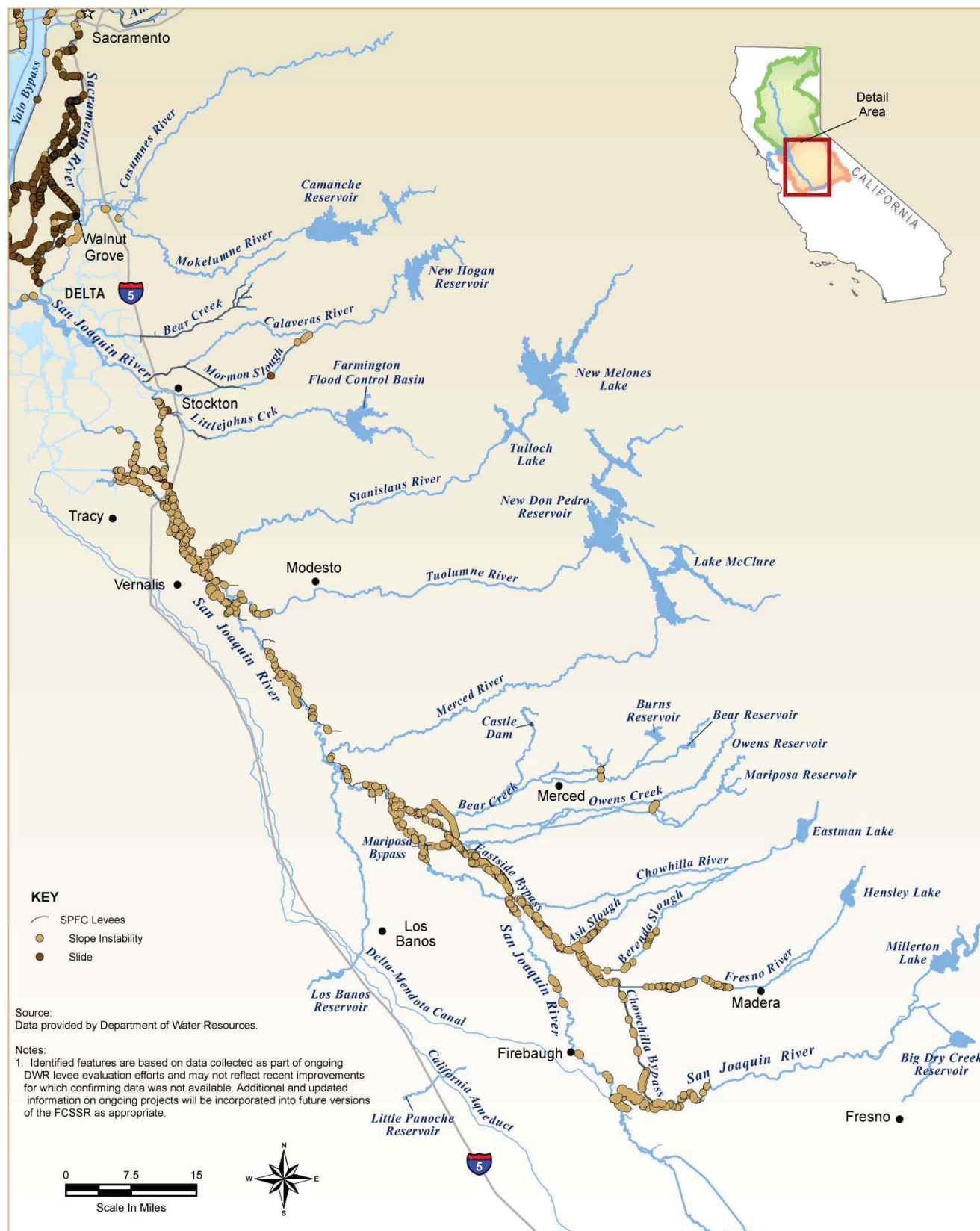


Figure A-19. Historical Slope Instability Occurrences in Sacramento River Watershed



## Flood Control System Status Report



**Figure A-20. Historical Slope Instability Occurrences in San Joaquin River Watershed**

### **Summary of Recent Remedial Actions**

Stability berms, revetment, and riprap have been installed through DWR's Levee Repairs Program after slope instability was reported. Problems were generally identified from inspections or as part of levee reconstruction projects that restore levees to current design criteria. Revetments and riprap sites for the Sacramento and San Joaquin river watersheds are shown in Section A-5, Erosion.

### **Summary of Ongoing and Planned Remedial Actions/Improvements**

Many slope stability problems are the result of inadequate levee geometry, erosion, or seepage problems. Several of the Early Implementation Program and USACE/Board projects shown in Section A-1 include levee improvements that address levee structural instability. DWR's Levee Repairs Program, described in Section A-2, also addresses structural instability.

### **Ongoing Actions to Improve Future Evaluations**

DWR continues to collect levee information using traditional and new, innovative methods, including LiDAR, surficial geomorphic mapping, and electromagnetic surveys.

## **A-5 Erosion**

This section includes results of DWR inspections and surveys for erosion and historical erosion occurrences. Recent, ongoing, and planned remedial actions and improvements, including revetment and riprap locations and erosion-related levee work planned and conducted by DWR, are included. Ongoing actions to improve future evaluations for erosion are also included.

### **Results of Inspections**

Sites with erosion problems were identified through the following data sources:

- Levee Inspection Reporting (DWR, 2010b)
- San Joaquin River Flood Control System Erosion Surveys (DWR, 2010c)
- Sacramento River Bank Protection Project Erosion Surveys (USACE, 2010)

### ***Levee Inspection Reporting***

As mentioned, DWR visually inspects SPFC levees for erosion problems at least twice a year, and reports results annually. Table A-15 shows the DWR inspection rating descriptions for erosion/bank caving on earthen levees.

**Table A-15. Levee Inspection Rating Descriptions for Erosion/Bank Caving on Earthen Levees**

<b>Inspection Rating</b>	<b>Rating Descriptions</b>
Acceptable (A)	No active erosion or bank caving observed on the landward or on the riverward side of the levee.
Minimally Acceptable (M)	There are areas where active erosion is occurring or has occurred on or near the levee embankment, but levee integrity is not threatened.
Unacceptable (U)	Erosion or caving is occurring or has occurred that threatens the stability and integrity of the levee. The erosion or caving has progressed into the levee section or into the extended footprint of the levee foundation and has compromised the levee foundation stability.

### ***San Joaquin River Flood Control System Waterside Erosion Surveys***

In 2006, DWR began an erosion survey program for the San Joaquin River Flood Control System to assist in documenting and monitoring erosion sites. The most recent report, *2009 Supplemental Erosion Survey of the San Joaquin River Flood Control System* (DWR, 2010c), includes an inventory of levee erosion sites on the San Joaquin River Flood Control System. Surveys are conducted annually, between July and October. Land-based surveys are conducted by inspecting the waterside levee and berm from the levee crown. In navigable waterways where the view of the waterside levee is obstructed, a boat is used to conduct the survey.

Erosion sites were ranked using criteria partly based on the *2007 Field Reconnaissance Report of Bank Erosion Sites and Site Priority Ranking* (USACE, 2007), and the *Erosion Screening Process Report* (DWR, 2009a). The criteria have been partially modified to suit the type of data collected for the San Joaquin River system. An overall rating was assigned to each site based on a normalized total weighted score of erosion criteria (berm width, vegetation cover, burrow holes, levee slope, soil type, site relative to bend, radius of curvature, length of erosion, scarp height, and location of erosion). Table A-16 shows the DWR inspection rating descriptions for the surveys.

**Table A-16. San Joaquin River Flood Control System Erosion Surveys Rating Descriptions for Erosion/Bank Caving on Earthen Levees**

Inspection Rating	Rating Description
Minimally Acceptable (M)	A site that receives a normalized score equal to or less than the average is rated M. The site should be monitored and assessed annually for erosion activity, as it may become a serious inadequacy in the next flood event.
Unacceptable (U)	A site that receives a normalized score greater than the average is rated as U. The site may require corrective action soon, because it may become a serious inadequacy that can fail in the next flood event.

***Sacramento River Bank Protection Project Erosion Surveys***

Sacramento River Bank Protection Project erosion surveys are described in Section 2.1.3, Joint USACE and DWR Inspections.

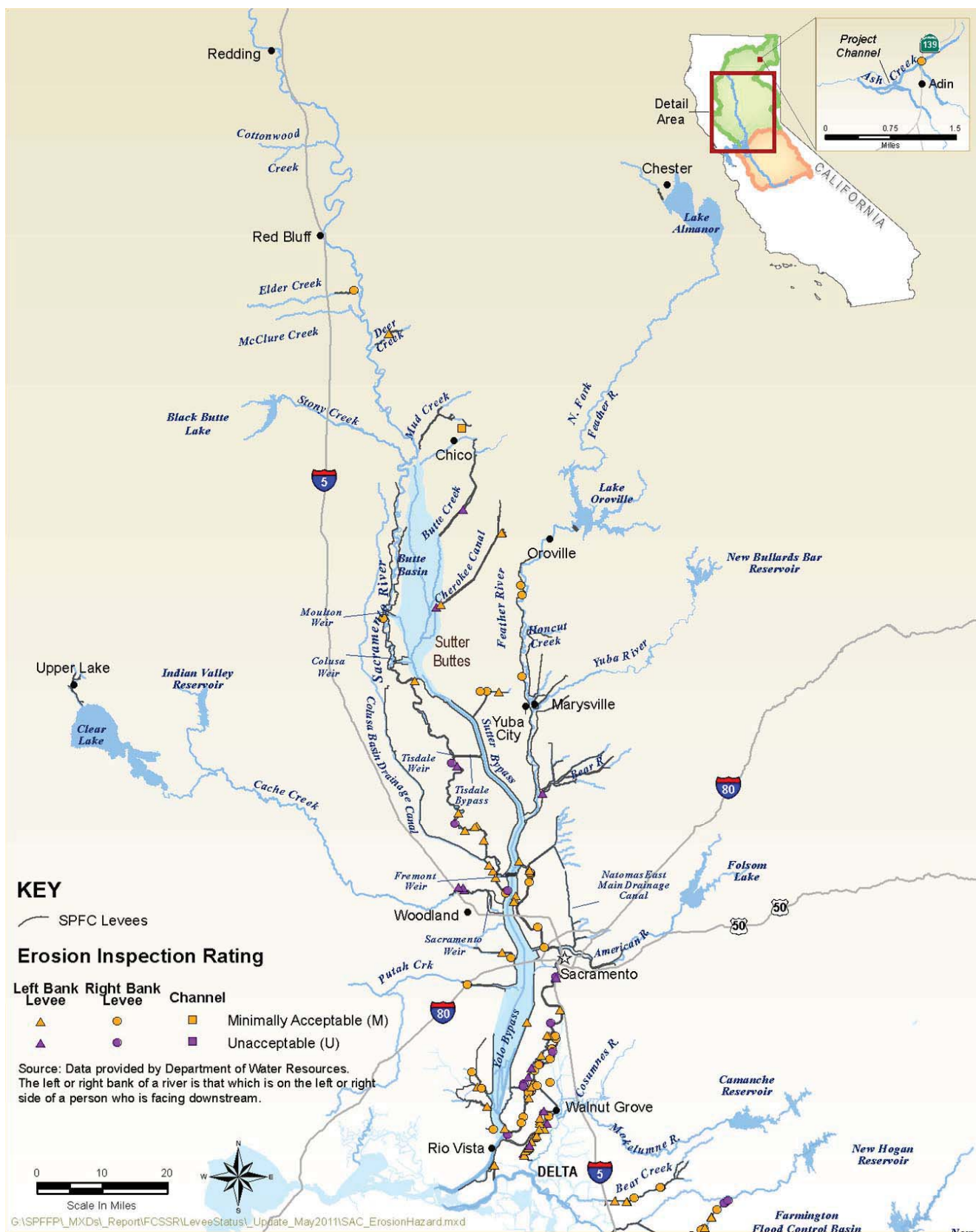
DWR Levee Mile Reports incorporate data from all three inspections and present them according to the rating descriptions for erosion/bank caving on earthen levees, as shown in Table A-15. Data from the *2009 DWR Levee Mile Reports* are shown on Figures A-21 and A-22. Minimally Acceptable and Unacceptable ratings for erosion are located sporadically throughout the Sacramento River watershed. The north Delta and lower Sacramento River south of Sacramento have a relatively high concentration of erosion sites. Most of the erosion sites in the San Joaquin River watershed are along the lower San Joaquin River north of the Stanislaus River and Mormon Slough.

***Limitations of Inspection Results***

Visual inspections provide limited information on levee conditions related to erosion. A typical levee inspection occurs from the crown of the levee, but erosion on the slope and beyond is sometimes not visible from this vantage point. In addition, thick vegetation and wide berms can also obstruct an inspector's view of an erosion site. Erosion surveys conducted by boat can improve on these limitations, but both the levee inspections and erosion surveys are limited to what is visible above the waterline from the top of the levee.



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**Figure A-21. 2009 Erosion Inspection Ratings in Sacramento River Watershed**





Figure A-22. 2009 Erosion Inspection Ratings in San Joaquin River Watershed

### **Historical Erosion Occurrences**

The ULE and NULE projects collected and cataloged information on historical occurrences of levee erosion and completed or planned repairs or improvements. Figures A-23 and A-24 show historical erosion occurrences for the Sacramento and San Joaquin river watersheds, respectively. Historical erosion occurrences were located throughout almost all SPFC levees of the Sacramento and San Joaquin river watersheds.

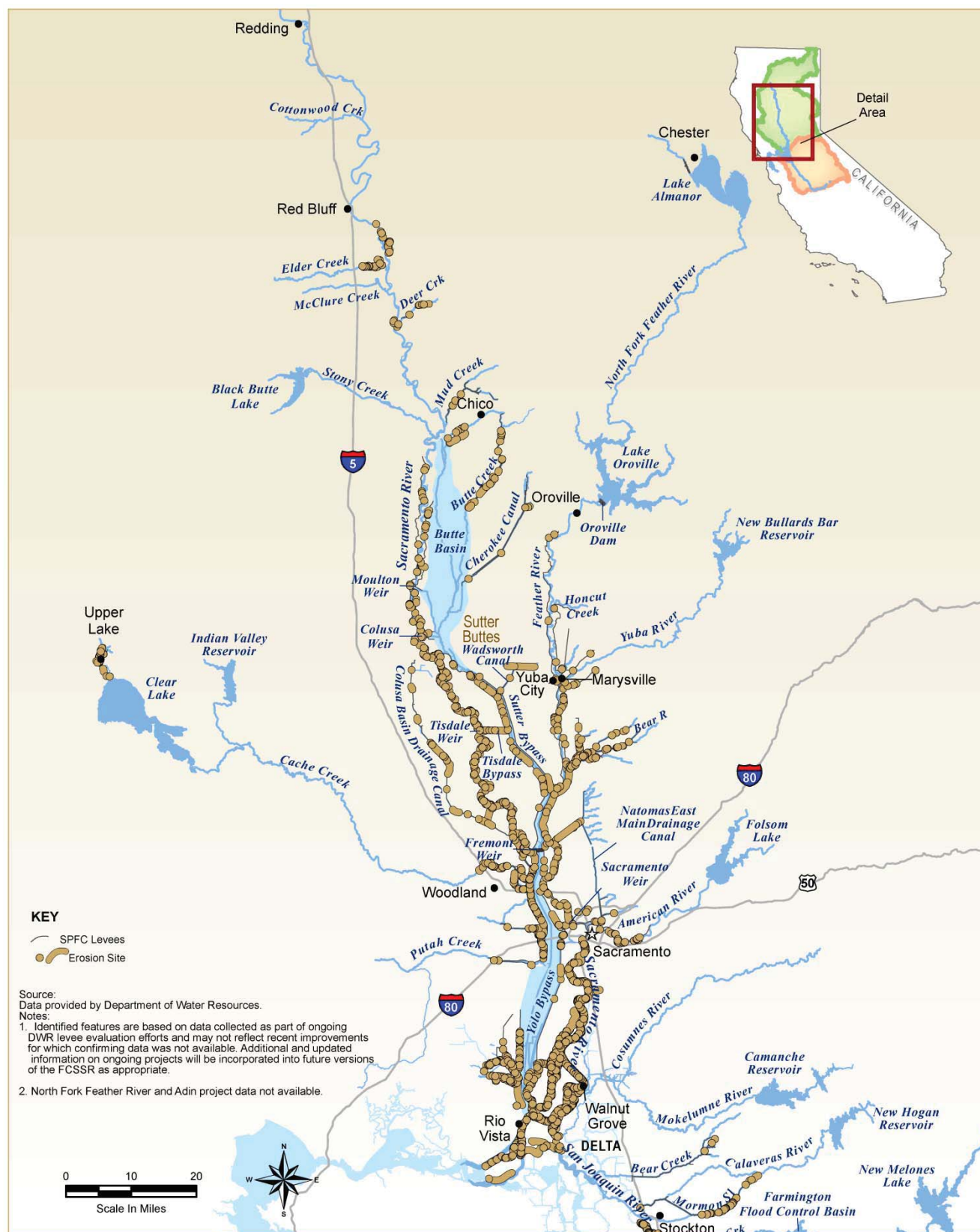
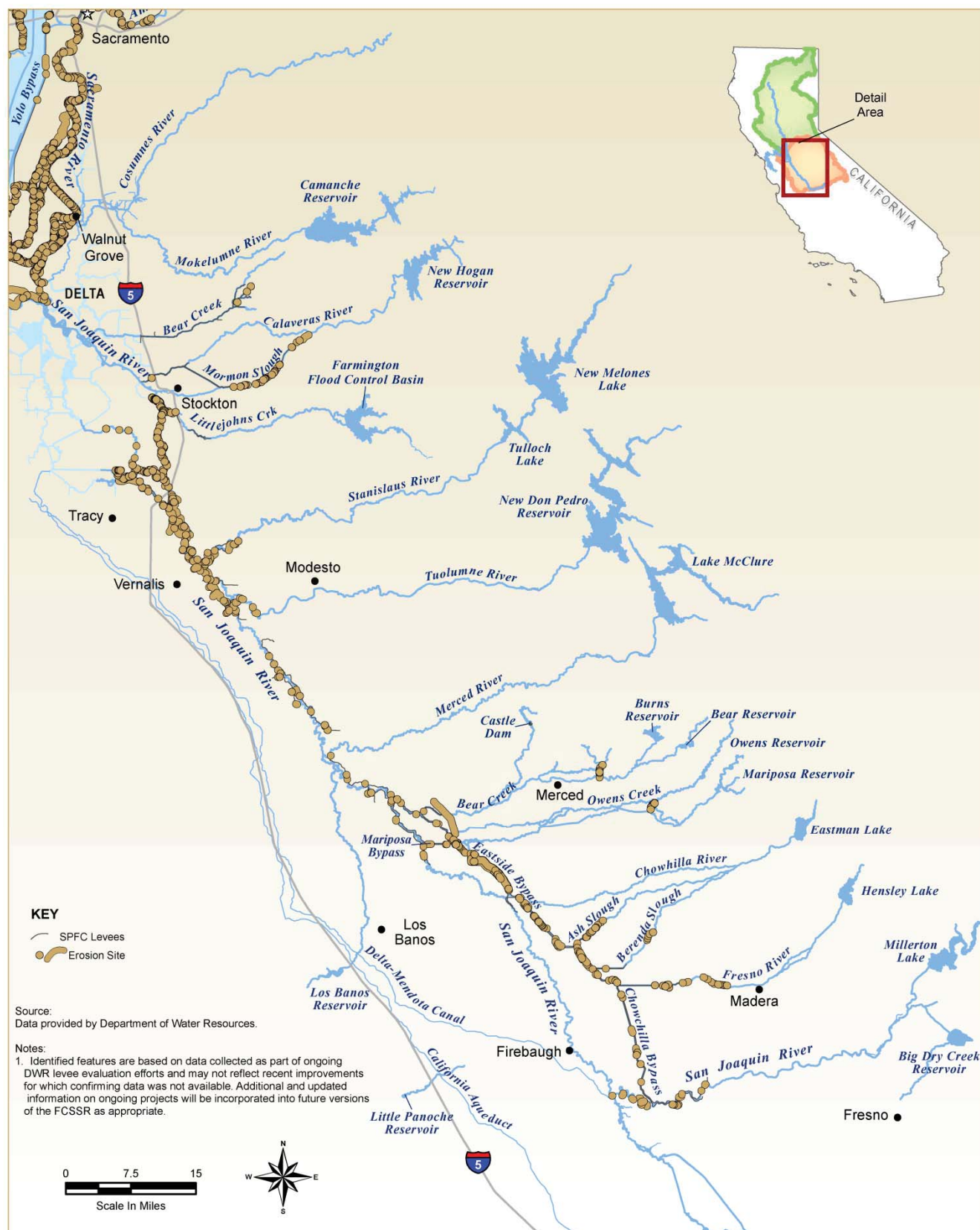


Figure A-23. Historical Erosion Occurrences in Sacramento River Watershed



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**Figure A-24. Historical Erosion Occurrences in San Joaquin River Watershed**

### **Summary of Recent Remedial Actions**

Revetment and riprap have been installed through DWR's Levee Repairs Program after erosion was reported from inspections to restore levees to meet current design criteria.

Information on observed revetment and riprap sites was collected and cataloged as part of the data collection efforts for the ULE and NULE projects, as described in this section. Figures A-25 and A-26 show observed revetment and riprap sites for the Sacramento and San Joaquin river watersheds, respectively. Revetment and riprap have been placed throughout the Sacramento and San Joaquin river watersheds.

### **Summary of Ongoing and Planned Remedial Actions/Improvements**

Erosion is identified and monitored by maintaining agencies to help identify locations that require remediation. DWR's Levee Repairs Program is described below, and many of the Early Implementation Program and USACE/Board projects identified in Section A-1 will preserve the integrity of SPFC levees with regard to erosion.

#### ***DWR Levee Repairs Program***

As mentioned, DWR's Levee Repairs Program addresses critically and not critically damaged levees, leveraging existing programs and authorizations. The following projects/programs address erosion problems:

- Sacramento River Bank Protection Project
- Sacramento-San Joaquin Erosion Repair Project
- Levee Stability Program
- Public Law 84-99 Rehabilitation Assistance Program

The Sacramento River Bank Protection Project is a federally authorized project with cost sharing between USACE and the Board for SPFC levees that are at risk of an erosion failure during floods and/or normal flow conditions. Waterside erosion surveys of the Sacramento River system conducted every year provide an inventory of erosion sites. As of December 2010, 83 erosion sites had been repaired and 173 were planned for repair (USACE, 2010).

The Sacramento-San Joaquin Erosion Repair Project is funded by DWR and local agencies for remediation of erosion sites across the Central Valley. The Sacramento-San Joaquin Erosion Repair Project will be used to repair erosion sites when the Sacramento River Bank Protection Project



authorization ends. As of December 2010, eight erosion sites had been completed and seven were planned for completion.

As mentioned, the Levee Stability Program is a federal program authorized by the Water Resources Development Act of 2007. Levee Stability Program sites are selected by the DWR Levee Evaluations Program. As of December 2010, two erosion sites had been recommended for repair, but additional sites are anticipated as the DWR Levee Evaluations Program continues.

As mentioned, the Flood Control and Coastal Emergency Act (Public Law 84-99) provides the federal government with authority for emergency management activities. After the 2005 – 2006 storms, 173 erosion sites were determined to be eligible for Public Law 84-99 assistance by USACE, all of which have been constructed.

Planned and completed erosion sites from the Sacramento River Bank Protection Project, Sacramento-San Joaquin Erosion Repair Project, the Levee Stability Program, and Public Law 84-99 projects are shown in Figures A-27 and A-28 for the Sacramento and San Joaquin river watersheds, respectively.

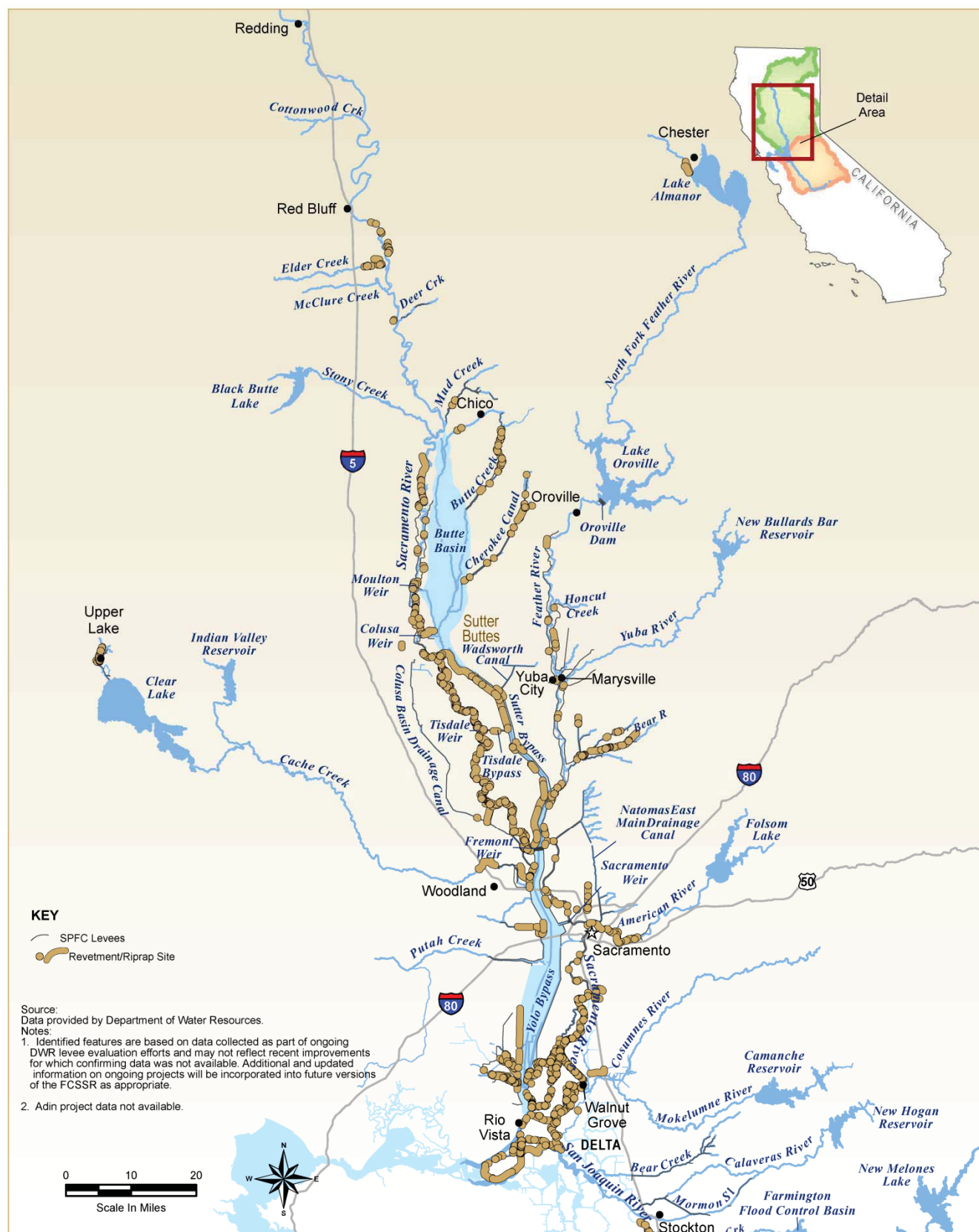
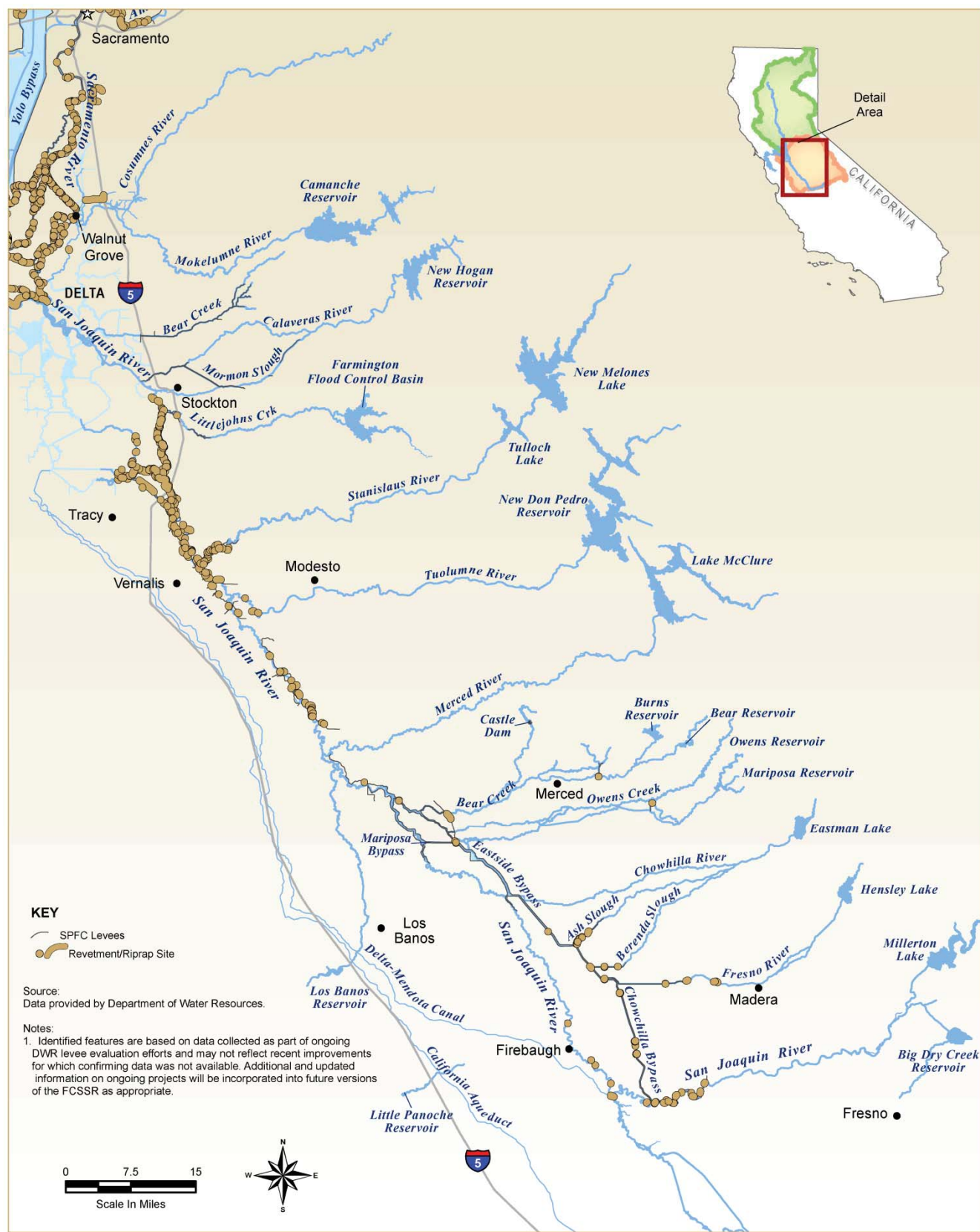


Figure A-25. Levee Revetment Sites in Sacramento River Watershed

## Flood Control System Status Report



**Figure A-26. Levee Revetment Sites in San Joaquin River Watershed**



**Figure A-27. Planned and Completed Erosion Repair Sites in Sacramento River Watershed**





**Figure A-28. Planned and Completed Erosion Repair Sites in San Joaquin River Watershed**



### Ongoing Actions to Improve Future Evaluations

DWR continues to collect levee information using traditional and new, innovative methods, including LiDAR, bathymetric surveys, and geomorphic mapping (see Section A-1). Bathymetric data are especially important in revealing underwater erosion of riverbanks that was previously unknown from waterside erosion surveys.

In addition, a U.S. Geological Survey Sacramento River Bank Protection Project Sedimentation Study is currently underway to evaluate sediment transport and bank stability within the Sacramento River Flood Control System. The study area extends along the Sacramento River from River Mile (RM) 46 at Freeport upstream to RM 144 at Colusa. The study consists of two phases. Phase 1 was completed in March 2009 and included collection and review of available data related to sediment transport and geomorphic trends within the study area. Phase 2 of the study will address the following objectives:

- Evaluate both long-term and flood event aggradation and degradation potential for Sacramento River system bed profiles.
- Evaluate the potential for aggradation at weirs that might affect flow distribution into bypasses.
- Assess the distribution of spawning gravels within the Sacramento River Flood Control Project today and 50 years in the future.
- Evaluate the potential reduction in riparian habitat and floodplain (potential loss of remaining overbank or “berm”) over the next 50 years.
- Assess implications of a sediment transport regime on long-term levee repair requirements for the Sacramento River Flood Control System.

Specific Phase 2 study tasks include sediment sampling, bank stability analysis, sediment transport modeling, and updates to HEC-RAS hydraulic modeling software to improve sediment transport calculation capabilities.

## A-6 Settlement

This section includes locations of observed sinkhole and subsidence occurrences and a description of recent, ongoing, and planned remedial actions and improvements, and ongoing actions to improve future evaluations.

### **Historical Sinkhole and Subsidence Occurrences**

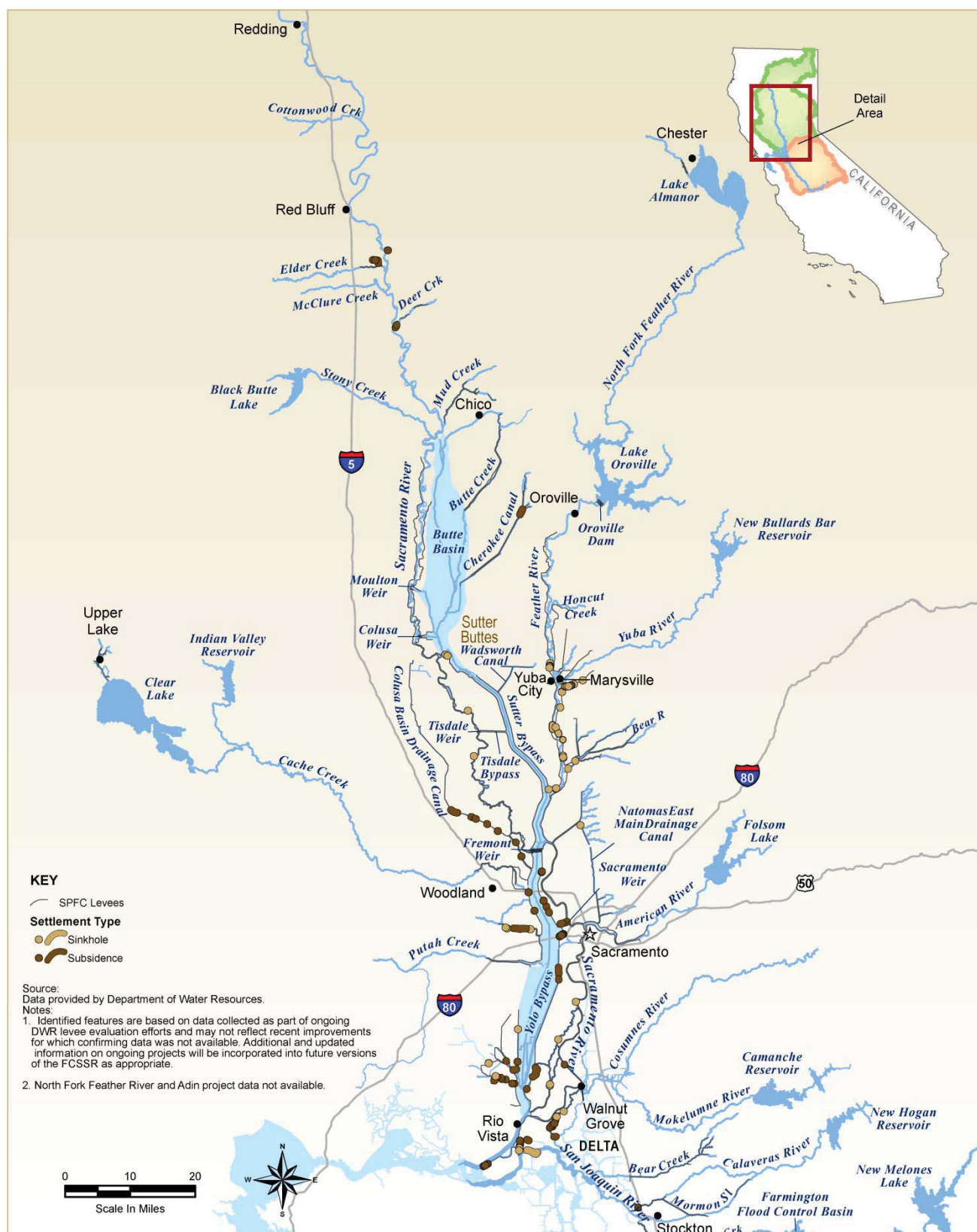
The ULE and NULE projects collected and cataloged information on historical occurrences of levee settlement and on completed or planned levee construction or improvements. Figures A-29 and A-30 show historical sinkhole and subsidence occurrences in the Sacramento and San Joaquin river watersheds, respectively. Most of the observed subsidence occurrences in the Sacramento River watershed are located along the Colusa Basin Drainage Canal and Yolo Bypass. Sinkholes are located sporadically across the Sacramento River watershed. In the San Joaquin River watershed, observed subsidence occurrences are located on the Eastside Bypass between Chowchilla River and Owens Creek and observed sinkholes are located on the Chowchilla Bypass.

### **Summary of Recent Remedial Actions**

DWR's Levee Repairs Program and recent other projects have remediated locations where settlement problems have been reported from inspection and evaluation activities.

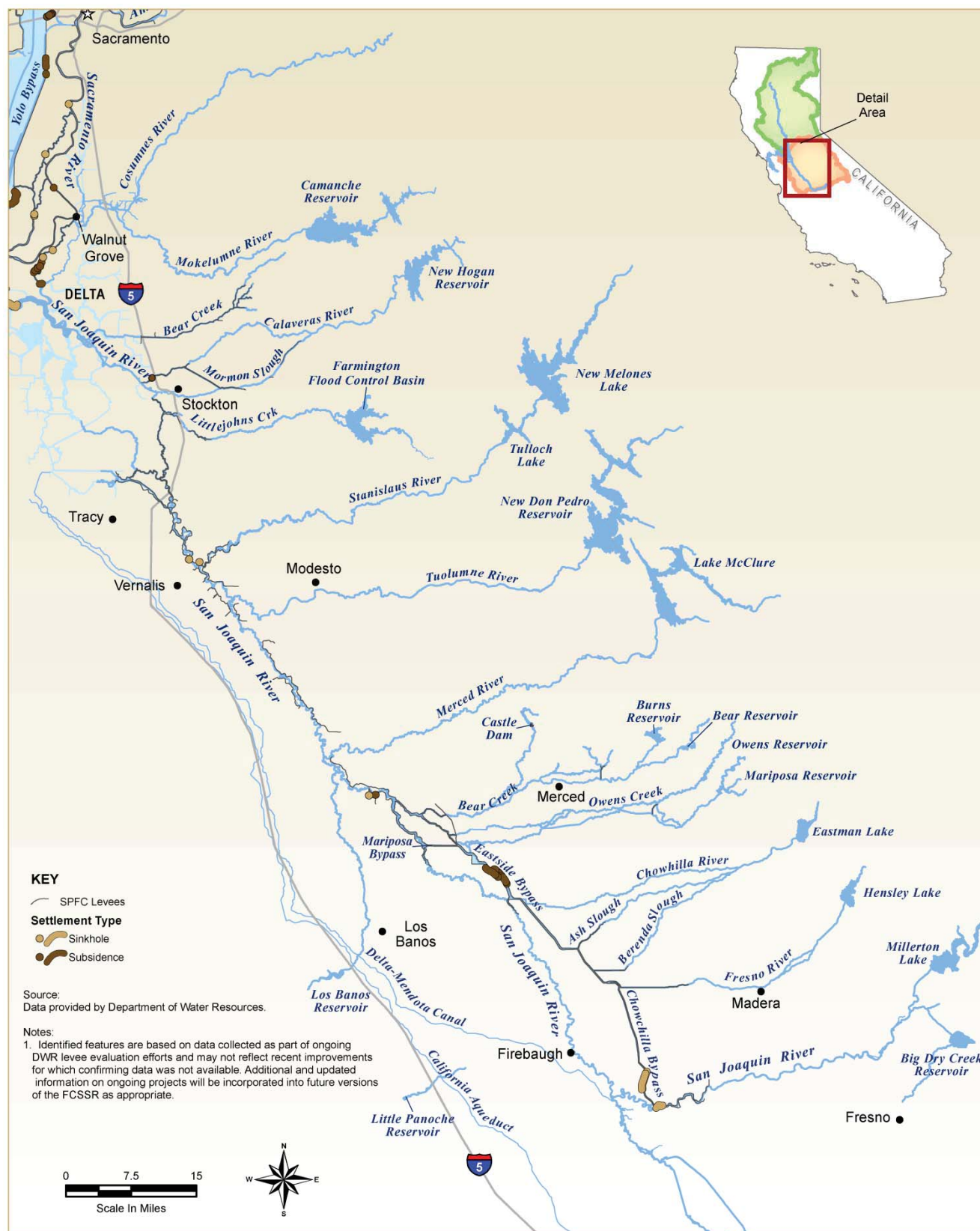
### **Summary of Ongoing and Planned Remedial Actions/Improvements**

Sinkholes and subsidence are identified and monitored by maintaining agencies to help identify locations that would require repairs or a construction project for remediation. Settlement problems are addressed through DWR's Levee Repairs Program and through other projects being implemented to address subsidence. DWR's Levee Repairs Program is described in Section A-3, and many of the Early Implementation Program and USACE/Board projects identified in Section A-1 will preserve and enhance the integrity of SPFC levees with regard to settlement.



**Figure A-29. Historical Sinkholes and Subsidence Distresses in Sacramento River Watershed**

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**Figure A-30. Historical Sinkholes and Subsidence Distresses in San Joaquin River Watershed**

## Ongoing Actions to Improve Future Evaluations

DWR continues to collect levee information using traditional and innovative methods, including LiDAR and geomorphic mapping (see Section A-1).

## A-7 Penetrations

This section includes a brief description of recent, ongoing, and planned remedial actions, and ongoing actions to improve future evaluations regarding penetrations.

### Summary of Recent Remedial Actions

In 2009, six penetration failures were initially reported by either the owner or observed by the maintaining agency. DWR conducted follow-up inspections and expeditiously repaired or replaced the pipes. A description and location of these penetrations is included in Table A-17.

**Table A-17. Penetrations Repaired or Replaced by DWR in 2009**

Penetration Description	Location
Leak in 14-inch-diameter pipe eroded soil and created a sinkhole approximately 6 inches in diameter, located 10 feet from waterside toe of the levee.	Calaveras River
Subsidence at paved levee crown due to collapse of a 12-inch-diameter pipe, located 3 feet below levee crown.	Sacramento River
Leaky 24-inch-diameter corrugated metal pipe created a 10-foot-diameter cavity in the interior of the clayey levee. A sinkhole, 3 feet in diameter appeared on the patrol road.	Sacramento River
Corroded 12-inch-diameter drainage pipeline (located roughly 3 feet below the crown) washed out a 10-foot-diameter, 6-foot-deep hole of the landside levee slope and crown. Severe erosion at the pipe location on the waterside of the levee was evident.	San Joaquin River
Severe leak in a 6-inch-diameter irrigation pipe caused distress on the sandy levee embankment. Pipe located about 3.5 feet below the landside toe.	Sacramento River
Leaky irrigation pipe crossing the levee damaged levee waterside slope. The damage extends for a length of about 15 feet extending almost the entire waterside slope.	Putah Creek

Most penetrations through SPFC levees are maintained by entities other than DWR. Information is not available to identify the number of pipes that may have failed or have been repaired or replaced by entities other than DWR.



### **Summary of Ongoing and Planned Remedial Actions**

DWR is continuing to inspect, identify, repair, and/or replace penetrations that could compromise the structural integrity of a levee. It is difficult to determine when remedial action is needed because internal erosion caused by penetrations often remains hidden until a surface expression occurs.

### **Ongoing Actions to Improve Future Evaluations**

Ongoing actions to improve future evaluations of penetrations include the DWR utility crossing survey program. The goal of the program is to develop a systemwide, searchable database of all existing utility crossings. The program will develop field survey protocols and a rating system or criteria to incorporate utility crossings into current inspection ratings through a pilot project. The program will then define the frequency and schedule for completing surveys systemwide.

## **A-8 Levee Vegetation**

This section includes the DWR *Interim Vegetation Inspection Criteria for Standard Levees* (DWR, 2007), and a description of recent, ongoing and planned remedial actions, and ongoing, actions to improve future evaluations.

### **DWR Interim Vegetation Inspection Criteria for Standard Levees**

The DWR *Interim Vegetation Inspection Criteria for Standard Levees* (DWR, 2007) are shown on Figure A-31.

### **Summary of Recent Remedial Actions**

Levee vegetation maintenance activities conducted by DWR and maintaining agencies include removing vegetation and downed trees that could obstruct the natural flow of water, and controlling weeds, grasses, emergent vegetation, and woody vegetation on levees. DWR's maintenance yards routinely identify and remove trees considered to have the potential to fall and undermine levees. Other specific routine maintenance activities include removing debris, spraying herbicides, mowing and burning vegetation on slopes, and dragging levee slopes.

### **Summary of Ongoing and Planned Remedial Actions**

New levee sections being constructed as part of current Early Implementation Program and USACE/Board projects (Section A-1) will be in compliance with USACE levee vegetation criteria. DWR and the Board require maintaining agencies responsible for maintenance of SPFC levees

to be in compliance with DWR interim vegetation criteria. Progress in implementing interim vegetation requirements will be reviewed by USACE, the Board, and DWR to assess progress in complying with milestones (California Levee Roundtable, 2009). Maintaining agencies are required to develop a plan to resolve vegetation problems. Finally, DWR's maintenance yards and other maintaining agencies will continue to routinely perform annual maintenance to remediate identified problems, such as identifying and removing trees considered to have the potential to fall and undermine levees.

# Flood Control System Status Report

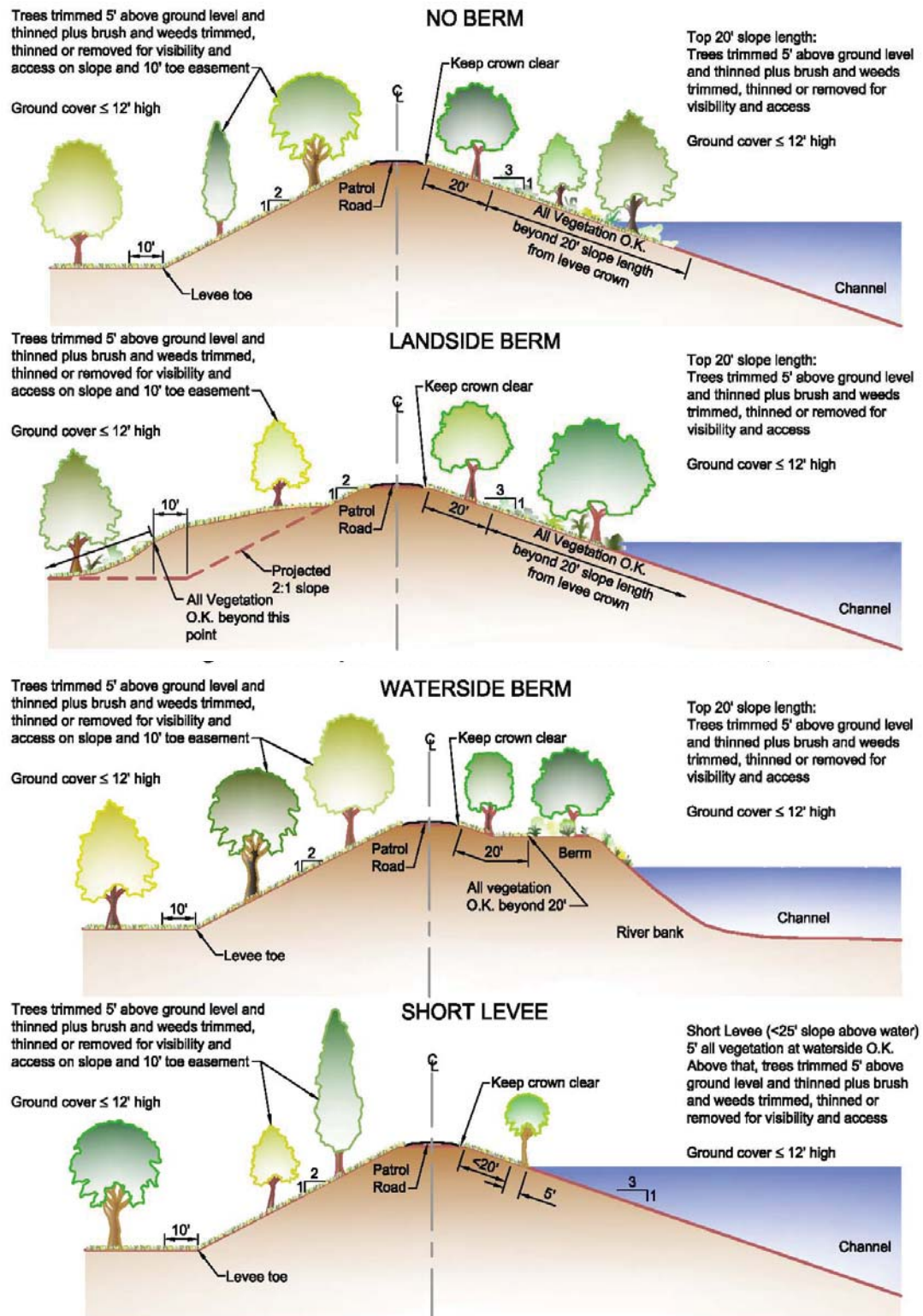


Figure A-31. DWR Interim Vegetation Inspection Criteria for Standard Levees, October 2007

### **Ongoing Actions to Improve Future Evaluations**

Differences between USACE and DWR levee vegetation criteria are significant enough that comparison of levees with USACE criteria would likely show more SPFC levees as noncompliant with current USACE criteria. DWR and USACE continue to work to resolve these differences.

DWR may implement additional changes to its inspection program as existing USACE policies are refined over time, and as other levee management issues arise. The California Levee Vegetation Research Program is being conducted by DWR in partnership with the Sacramento Area Flood Control Agency, Board, U.S. Fish and Wildlife Service, National Oceanic and Atmospheric Administration, California Department of Fish and Game, and local agencies that are members of the California Central Valley Flood Control Association. The partnership conducts research that will determine the extent to which woody vegetation, such as trees, may affect the safety of levees in the Central Valley. The research is being conducted in parallel with a complementary national research program underway by USACE.

## **A-9 Rodent Damage**

This section includes the results of DWR annual inspections for animal control, and a description of recent, ongoing, and planned remedial actions, and ongoing actions to improve future evaluations.

### **Results of Inspections**

DWR visually inspects SPFC levees for burrowing rodent damage at least twice a year, and reports results annually. Table A-18 shows the DWR inspection rating descriptions for animal control of burrowing rodents.

**Table A-18. Levee Inspection Rating Descriptions for Animal Control on Earthen Levees**

Inspection Rating	Rating Descriptions
Acceptable (A)	Continuous animal burrow control program in place that includes elimination of active burrowing and filling in and compacting or grouting of existing burrows.
Minimally Acceptable (M)	The existing animal eradication and burrow repair program needs to be improved. Several animal burrows present that may lead to seepage or slope stability problems. Burrows must be filled and compacted or grouted.
Unacceptable (U)	Animal burrow control program is not effective or is nonexistent. Significant maintenance is required to fill existing burrows, and the levee will not provide reliable flood protection until this maintenance is complete.

Animal control inspection ratings from the *2009 Annual Inspection Report* (DWR, 2010b) are shown on Figures A-32 and A-33 for the Sacramento and San Joaquin river watersheds, respectively. The inspection data show that several levees were given Minimally Acceptable ratings across the Sacramento River watershed, especially along the upper Sacramento River north of Fremont weir, American River, and Feather River. In the San Joaquin River watershed, Unacceptable and Minimally Acceptable ratings are prevalent throughout the watershed.



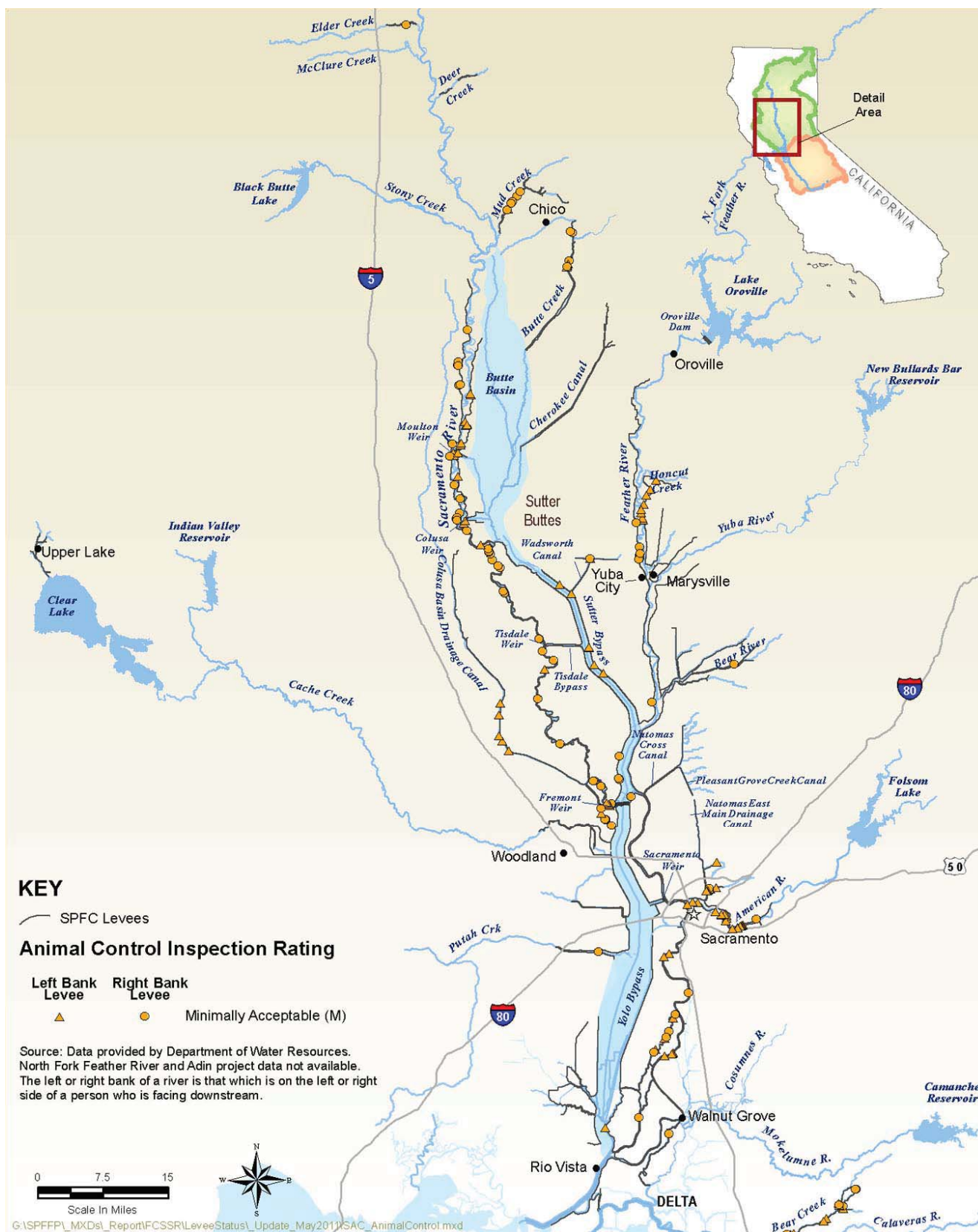


Figure A-32. 2009 Animal Control Inspection Ratings in Sacramento River Watershed

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**Figure A-33. 2009 Animal Control Inspection Ratings in San Joaquin River Watershed**

### **Summary of Recent Remedial Actions**

Maintaining agencies are responsible for rodent abatement and damage repair, and implement their own rodent abatement programs. While rodent abatement practices vary among maintaining agencies, current remedial actions under DWR's Rodent Abatement Program include the following:

- Continuous monitoring of all DWR-maintained levees for rodent activity.
- Year-round application of rodent bait, as needed.
- Application of sulfur gases to some rodent runways and dens in areas frequently visited by the public and domestic animals.
- Grouting all newly discovered rodent runways and dens once a year.

### **Summary of Ongoing and Planned Remedial Actions**

Remedial actions for rodent abatement/damage repair are currently not planned to change. Remedial actions will be implemented annually by maintaining agencies as problems are noted in inspections.

### **Ongoing Actions to Improve Future Evaluations**

Increased communication between USACE and DWR regarding inspections is currently taking place to improve evaluation and lead to quicker and more thorough repair of rodent damage.

With the initial identification of levee reaches affected by animal burrows completed through the DWR Animal Burrow Hole Persistence Study, additional efforts could be performed to further examine the incidence of animal burrows on levees such as (1) measurement of burrow hole density and prevalent hole diameter, (2) assessment of maintenance practices to control animal population and mitigate damage to levees, (3) identification of animal species involved, and (4) correlation of animal species activity with habitat and land use.

## **A-10 Encroachments**

This section includes a description of recent, ongoing, and planned remedial actions, and ongoing actions to improve future evaluations.

### **Summary of Recent Remedial Actions**

The Board is responsible for reviewing applications and issuing permits for encroachments within SPFC easements. DWR inspectors perform the field

inspections of most permitted encroachments to determine that they are constructed or installed in accordance with permit conditions. DWR inspectors also document illegal (unpermitted) encroachments and inadequately maintained permitted encroachments in SPFC easements. DWR relies on maintaining agencies to help identify and remove illegal encroachments.

Assembly Bill 1165 was passed in October 2009, which gives the Board more authority for encroachment enforcement. The Board recently developed regulations to implement its new enforcement authorities. The Board has the authority to request removal of unpermitted or inadequately maintained encroachments. The Board created a new Floodway Encroachment and Enforcement Branch to permit, regulate, and enforce the Board's decisions regarding the significant number of encroachments on levees, in floodplains, and near regulated streams within the SPFC. Between May 2009 and December 2010, 50 enforcement actions in Central Valley have been initiated; 14 of those have been resolved.

### **Summary of Ongoing and Planned Remedial Actions**

DWR will continue to inspect construction or installation of newly permitted encroachments in accordance with permit conditions. DWR will also continue to document and report new illegal encroachments and inadequately maintained encroachments to maintaining agencies and the Board for remedial actions.

Each maintaining agency is held responsible for preventing the construction of, or requiring the removal of, any illegally encroaching structures or activities on levees or within the easement at the landward toe of levees. The maintaining agency must also stop any unauthorized modifications or alterations to levees. If any person or organization deems any construction or modification necessary within a levee regulatory easement, that person or organization must apply for an encroachment permit.

### **Ongoing Actions to Improve Future Evaluations**

As a part of ongoing efforts to improve documentation and maintenance for the SPFC, DWR, and the Board have the following efforts currently underway or planned to begin soon, that affect encroachments:

- Continue to update existing levee logs to include data from O&M manuals, existing inspection results, and historical data. This information will be placed into a database format that will function as documentation of system features and structures. All data will be field-verified and georeferenced.

- Create a georeferenced database of the historical encroachment permits and use this effort with the updated levee logs to assist in determining which encroachments are permitted, and the number and type of unpermitted encroachments.



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## Acronyms and Abbreviations

Board .....	Central Valley Flood Protection Board
CVFPP .....	Central Valley Flood Protection Plan
DWR .....	California Department of Water Resources
FCSSR .....	Flood Control System Status Report
LiDAR .....	Light Detection and Ranging
NULE .....	Non-Urban Levee Evaluations
O&M .....	operations and maintenance
RM .....	River Mile
SPFC .....	State Plan of Flood Control
State .....	State of California
ULE .....	Urban Levee Evaluations
USACE .....	U.S. Army Corps of Engineers

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